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The Dock & Harbour Authority

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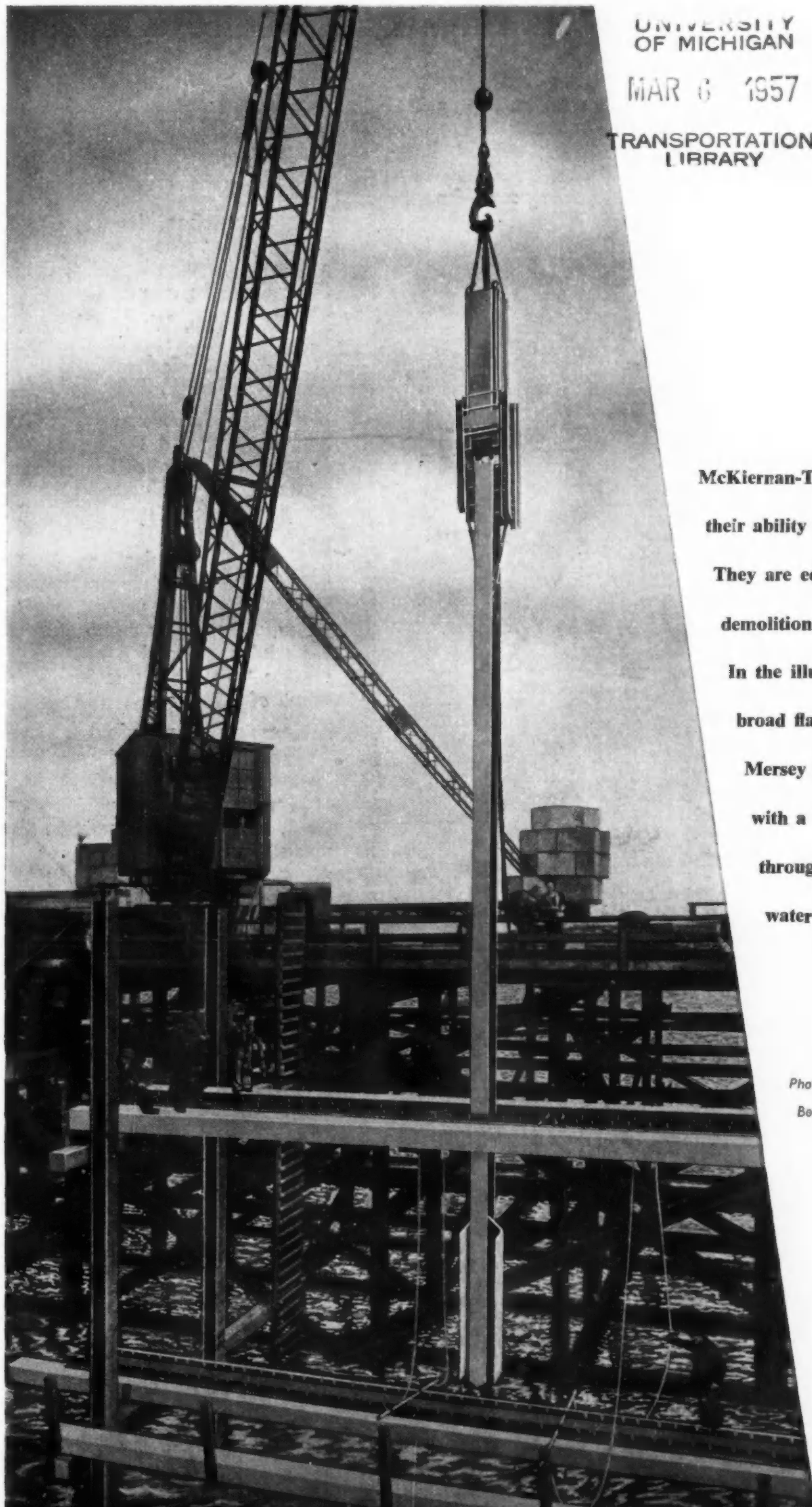


Dredging in Australia . . .

All-round popularity of the Priestman System

Since 1879, a steady flow of Priestman Grab Dredging Equipment has left Hull for Australia. At least 80 Priestman Grab Dredgers are now operating in that country, and among the Australian Harbour Authorities who have purchased Priestman plant since the war are—Brisbane, Perth, Launceston, Sydney and Melbourne.

Melbourne Harbor Trust

In 1949 this important Authority took delivery of a Priestman No. 60 size diesel driven grab dredging crane of 3 cu. yds. capacity. This dredger has carried out a great deal of work for the Trust including, amongst other things, salvage work for which of course the grab dredge is particularly well suited.

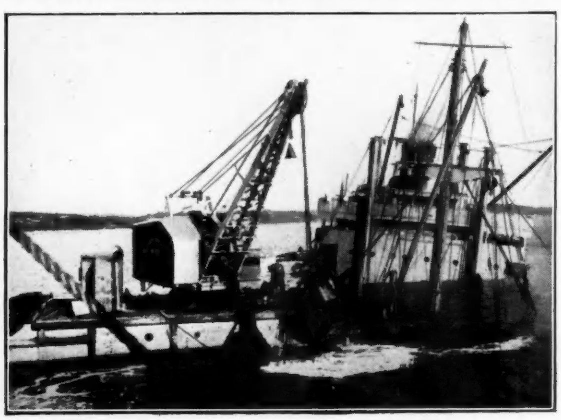
As a result of their experiences with this first machine the Harbor Trust have placed an order for a similar machine which will be delivered in the middle of 1957.

The Maritime Services Board, Sydney, N.S.W.

In addition to two earlier Priestman dredgers, the "Pan" and the "Duplex," this Board have a post-war Priestman No. 60 size steam-driven dredging crane of 3 cu. yds. capacity mounted on the grab hopper dredger "Burra Bru," built by the Morts Dock & Engineering Co. Ltd.

This vessel, with a hopper capacity of 300 tons, has a length of 131-ft., a breadth of 28-ft., a depth of 12-ft. with a loaded draft of 10-ft. Propelled by twin screws with engines developing 700 I.H.P., it has a loaded speed of 10¼ knots. On trials the hopper was filled in less than two hours with 66 lifts by the dredging crane.

(Photograph of the "Burra Bru" reproduced by courtesy of the Maritime Services Board).



Harbours and Marine Dept., Brisbane

After their original Priestman dredger had rendered 62 years of service, this Authority ordered their second Priestman. This was a Priestman No. 60, 3 cu. yd. diesel driven dredging crane which they mounted on their own barge, the "Tridacna."

This dredger discharges spoil into barges alongside which are then towed away for the spoil to be dumped at distances of up to 18 miles.

In 477 working hours the dredger raised over 30,000 barge yards of mud and sand at a cost of approximately 1/6 per cubic yard excluding capital costs.

In November the Harbours and Marine Dept. placed another order for a 2 cu. yd. diesel driven Priestman Grab dredging crane.

P.W.D., Perth, Western Australia

The grab dredger "Fremantle" was built for the P.W.D. of the Western Australia Government by the Morts Dock and Engineering Co. Ltd. of Sydney. This dredger, which has a hopper capacity of 320 tons, has dimensions as follows: length 136-ft., breadth 34-ft., depth 10-ft., loaded draft 7-ft. 9-in.

Fitted with a Priestman No. 40 size diesel driven dredging crane; operating either a 2 cu. yd. mud grab or a 1½ cu. yd. grab for stones and similar material, the vessel has a 350 B.H.P. marine type oil engine with a loaded speed of 8.8 knots.

Launceston, Tasmania

The Marine Services Board at Launceston purchased their first Priestman dredger in 1884, and in 1951, although their original dredger was still in operation, they decided to purchase a second Priestman. This new order covered the supply of a Priestman No. 20 size diesel driven dredging crane which operates a 1 cu. yd. mud grab at a maximum radius of 28-ft. In addition to carrying out normal dredging work, one vessel is also employed for coaling the Board's other dredger and is kept fully employed within the Harbour area.

ILLUSTRATIONS

Top right—Perth Public Works Dept. Grab-Hopper Dredger "Fremantle."

Centre—The Maritime Services Board, Sydney, Grab-Hopper Dredger "Burra Bru" working in Sydney Harbour.

Bottom—The Melbourne Harbor Trust Pontoon-mounted Dredger assisting in salvage operations.

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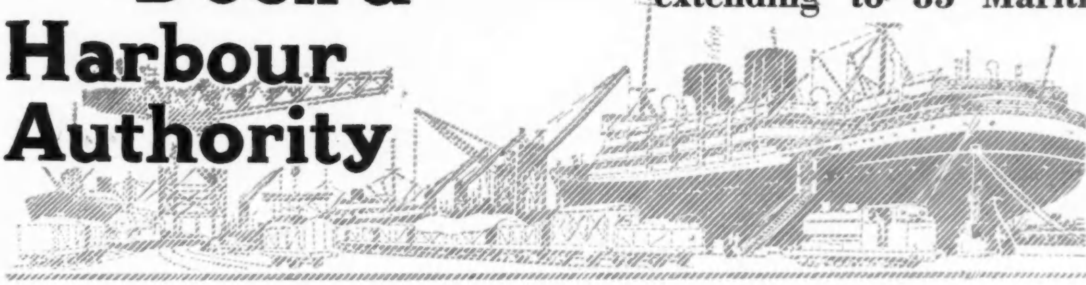

No. 436

Vol. XXXVII

FEBRUARY, 1957

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Editorial Comments

Ports of the Delaware River, U.S.A.

The Delaware River Port Authority was created on July 17, 1952, following an agreement between the Commonwealth of Pennsylvania and the State of New Jersey. The Authority is composed of sixteen commissioners, comprising eight resident voters from each of the states. Its main purpose is to develop and improve the Port District and to promote the Delaware River as a commercial and industrial centre of the United States. A description of its considerable facilities forms the subject of our leading article for this month.

Philadelphia and her sister ports on the Delaware River have many natural advantages which have substantially contributed to the present prosperity of the area. Navigable throughout the year, the River is tidal as far as Trenton with a channel depth of 40-ft. from the mouth to Philadelphia and, thereafter with depths varying from 37-ft. to 25-ft. at the head of navigation. The Port of Philadelphia itself is located 100 miles inland from the sea and is favourably situated at the strategic centre of the greatest concentration of industry and population on the Atlantic seaboard. It is also in direct contact with the world's principal trade routes. The land alongside the River is for the most part level, lending itself easily to industrial construction and development. Parallel to the River runs a comprehensive range of transport facilities, railways and highways linked by modern bridges.

As a result of the favourable geographic conditions, industries have concentrated on the Delaware, and to-day the River port area is the largest oil refining centre on the East Coast and the second largest in the United States. More imported crude petroleum is unloaded from tankers in the Delaware River Port area than in all the other American ports combined. It is also an important chemical manufacturing and steel producing centre. There are large sugar refining and paper manufacturing installations and also grain handling and storage plants.

The Delaware River Port Authority is the second largest port of the United States in terms of total tonnage handled and, to keep pace with its increasing commitments, the Authority have in hand ambitious improvement plans. One of the largest of these is a scheme for a new general cargo terminal in the South Philadelphia area, which will include facilities for roll-on-roll-off trailer truck operations. There also will be berthing space for five ocean-going vessels at marginal wharf-type berths, which will be equipped with transit sheds having an overall capacity of 500,000 sq. ft. Other extensions and new construction works are being undertaken at a number of the ports along the River. It is, of course, not possible to describe these in detail in one article which has, perforce, to deal generally with the overall picture. However, it is hoped to give in a forthcoming issue a fuller description of the new ore pier at Philadelphia.

Forecasting the Measurement of Waves.

The rational design of structures, exposed to the action of the sea, depends largely on the availability of adequate information concerning the heights and periods of the waves and tides which are likely to occur in the area.

Experimental methods of predicting tidal phenomena were developed many centuries ago. It is, moreover, nearly 300 years since Newton laid the foundations of modern tidal theory. On the other hand the ability to predict the wind generated waves of the sea is of much more recent origin, and the methods used are still based very largely on empirical relationships. These wave forecasting methods are as yet much more limited and far less precise than comparative tidal predictions. However, even if wave characteristics are accurately forecast, the modification which they undergo on running into shallow water results in significant changes in wave height and direction. Satisfactory information can usually only be obtained by installing wave measuring devices and for this purpose many different wave recorders have been designed and tested in recent years.

On page 335 of this issue is an article which draws attention to the principles and practice of photogrammetry, and indicates its potentialities and limitations as applied to the measurement of waves. The authors have recently used experimental cameras to assess the type of apparatus and technique suitable for wave recording work using stereophotogrammetric principles. Their experiments lead them to believe that greater use could be made of this method, in particular when methods involving physical contact with the water are impracticable or impossible.

Ubiquity of the Dock Labour Problem.

This journal has printed several articles on the above mentioned subject since the publication in June last of the Devlin Report on the operation of the National Dock Labour Scheme. The reason why this has been done can be stated simply. The experience of recent years has shown beyond reasonable doubt that the Scheme is not satisfactory in its present form. In the opinion of many practical people, the Devlin committee came to the conclusion against the evidence of experience. The port industry is too important to this country for a policy of laissez-faire to be adopted towards it and sooner or later the operation of the Scheme must be examined again.

Great Britain is not the only nation in difficulty with dock labour arrangements and the core of the problem here and elsewhere seems to be the finding of a means or a system to decasualise the labour force without reducing its efficiency. The answer to this problem is being sought in Eastern as well as Western maritime countries and on a later page of this issue are printed extracts of an article on " Dock Labour in Japan," which was published in the September, 1956, number of the International Transport Workers Federation Journal. The Unions as well as port employers and port employees, are vitally concerned with this matter and it is their point of view, of course, which the article stresses.

Also printed in this issue is a summary of the most recent annual report of the Waterfront Industry Commission of New Zealand, from which it will be seen that here, too, there are dock labour problems similar to those which harass other maritime nations. New Zealand's port work is intermittent—as is shown by the fact that, during the year under review, her eleven main ports had some 108,000 man-days surpluses and about 107,000 man-days shortages. Work often starts late and finishes before the proper time; there is concern about non-productive time and about the effectiveness of supervision. As explained in the report, the question of supervision is closely related to the conditions under which labour is employed and it will surprise many people to learn that in the port of Wellington, labourers in permanent employment voted by a two to one majority in favour of casual employment. One particular sentence in the Commission's report again emphasises the point we have been making in this journal in recent months. " The efficiency of this vital industry," the report states, " largely depends on the quality of supervision exercised by the employers." Suffice to add that supervision cannot be efficient

Editorial Comments—continued

unless supervisors have reasonable powers. Under the British Dock Labour Scheme, disciplinary action is taken not by the employer who engages the labour but by another organisation too remote to undertake this vital task efficiently and quickly.

Choosing the Right Dredger.

An important paper on this subject has recently been read before the Maritime and Waterways Division of the Institutions of Civil Engineers by Dr. J. A. Ringers who is one of the foremost practising authorities on dredging work. We are pleased to be able to publish a shortened form of his paper in this issue. Dr. Ringers outlines the past and present-day development of dredging equipment in relation to the growth of ocean trade and to the increasing importance of the inter-ocean canals, and then presents this survey as a background to his statement of the factors which influence the choice of the dredging equipment required for a particular job.

The subject matter is expanded by some instructive notes upon each of the factors involved and Dr. Ringers concludes that for planning harbour or dredging work, the information and past records normally available are quite inadequate. A suggestion is made that records of tides, winds, typhoons, coastal currents and sea bottom strata and movements should be assembled on an international basis under the control of the United Nations Organisation. The author points out that the value of these records would be proportional to the time taken in compiling them, and that a start should be made now in order to assist the less privileged countries where improvements in agriculture and some industrialisation are urgently required.

Topical Notes

Equipment of Dock Locomotives with Radio Telephone.

The Tyne Improvement Commission will this Spring be installing V.H.F. radio telephone equipment on nine of their fleet of dock shunting diesel and diesel-electric locomotives at Tyne Dock, Co. Durham. If, after a period of trial, the anticipated saving in locomotive working is achieved, the system will be considered for the Commission's locomotives at Albert Edward and Northumberland Docks, North Shields.

The equipment will provide two-way telecommunication between the locomotives and a single control station, and will enable the supervisory staff to have immediate contact with individual locomotives wherever they are working. It is anticipated that locomotive running time will be saved, waiting time will be reduced and that benefits will result during fog conditions. A re-deployment of certain of the operating personnel should result in an increase in the number of wagons handled per loco hour worked.

A contract has been placed with Marconi's Wireless Telegraph Co. Ltd., to include for the maintenance of the fixed control and mobile stations. The former will operate from A.C. mains supply (250 volts, 50 cycles) and have a telephone-type hand set and transmitter/receiving unit mounted in a two-bay rack. A di-pole aerial on a 40-ft. high aerial mast will transmit at between 10 and 14 watts on a frequency allocated by the G.P.O. to a tolerance of plus or minus .01 per cent. The mobile stations will be mounted on shelves in the locomotive cabs and will operate from either a 12-volt or a 24-volt D.C. supply from the locomotive batteries. Each telephone equipment comprises a transmitter/receiving unit, separate power supply unit, and a control unit incorporating a loud speaker with separate press-to-talk switch and hand microphone. The standard loud speakers are modified to give increased audio output to compensate for the high mechanical noise level in the locomotive cabs. A short quarter-wave whip aerial will be mounted within the standard loading gauge.

The equipment, which will be supplied and placed on net by Marconi's Wireless Telegraph Co. Ltd., will be installed by the Commission.

Chair in Structural Engineering.

It was recently announced that the Councils and Governors of the College of Science and Technology, Manchester, have approved the appointment of Mr. Wilfred Merchant, M.A., D.Sc., S.M., M.I.Struct.E., to the newly created Chair in Structural Engineering in the Faculty of Technology of the University of Manchester and The Manchester College of Science and Technology. This is the first Chair of Structural Engineering to be established in the United Kingdom.

Educated at Manchester Grammar School and at Corpus Christi College, Oxford, Dr. Merchant graduated with first class honours in 1933. After a short period in industry, he was awarded a Commonwealth Fellowship and studied in the U.S.A. at the Massachusetts Institute of Technology, where he obtained a Master of Science degree in Civil Engineering in 1939. He qualified for the degree of Doctor of Science in the Manchester University in 1955.

Dr. Merchant spent the whole of the war period on mechanical and aerodynamic work which involved a large variety of structural problems. He entered academic life as a lecturer in Structural Engineering in the Manchester University and the then Manchester College of Technology in 1946, and was appointed Reader in Applied Mechanics in the Faculty of Technology in 1951. His appointment to the Chair of Structural Engineering reflects the growing recognition of the major importance of this subject in the United Kingdom.

Soil Mechanics and Foundation Engineering Conference.

Details have now been issued about the Fourth International Conference of the International Society of Soil Mechanics and Foundation Engineering, which is to be held in London from the 12th to 24th August this year. The Society, whose President is Professor Karl Terzaghi, Professor of the Practice of Civil Engineering, Harvard University, has over 3,000 members from 29 different countries, though attendance at the Conference is not restricted to members.

Soil Mechanics, or the "scientific study of soil as an engineering material," is a comparatively new science, dating largely from Professor Terzaghi's own investigations in the 1930s. To-day Great Britain and other countries have many laboratories for studying the subject.

The former conferences held at Cambridge, Massachusetts, Rotterdam and Zurich, have been attended by upwards of 800 delegates, but, owing to the growing interest, preparations are being made to accommodate an even larger number for the London Conference. Arrangements are also being made for tours to various parts of Great Britain to show something of the scenery, historic places, and industrial life.

The Chairman of the organising committee is Dr. W. H. Glanville, Director of the Department of Scientific and Industrial Research, Road Research Laboratory. The Council of the Institution of Civil Engineers have placed the Institution building at the disposal of the Society for the technical programme of the Conference, and full details and application forms to attend can be obtained from the Society's Secretary, Mr. A. Banister, O.B.E., The Institution of Civil Engineers, Great George Street, London.

Pension Scheme for Professional Engineers.

The problem of providing for his family and for a retirement pension is a matter of serious concern, not only to individual engineers but also to those employing them. Over the years, advancement in the profession often means changes which may involve moving from one situation to another so that a man cannot be covered by the usual type of scheme.

The Engineers' Guild has been working on this problem for some years and in conjunction with a leading firm of pension advisers and a well-known Life Insurance Company has produced a scheme which should be of great benefit to all professional engineers, whether self-employed or not.

The scheme is open to all members of the Guild and to members of the Institutions of Civil, of Mechanical and of Electrical Engineers who are eligible to become members and associates of the Guild; who are between the ages of 21 and 60; and who are normally resident in the United Kingdom or such countries as may be approved.

It is believed that this is the first Pension Scheme of its kind ever to be designed for members of a profession as a whole; it may well, therefore, become the pattern of schemes for other professions with similar problems.

The Ports of the Delaware River (U.S.A.)

Development and Improvement of Extensive Facilities

By J. ALEX. CROTHERS, Director, Port Development Dept.

FROM the Capes of the Delaware to the head of navigation at Trenton, New Jersey, the Delaware River provides a strategically located water highway 135 miles long. Dotting its banks are many port communities: Philadelphia, Chester, Marcus Hook, Fairless, and Bristol in Pennsylvania; Camden, Gloucester, Paulsboro, Trenton, Deepwater Point, and Burlington in New Jersey; and Wilmington in Delaware. Collectively, these ports form the Delaware River Port. The largest is Philadelphia, located 100 miles from the Atlantic Ocean. Its harbour covers 23 miles of waterfront on the Delaware River and 8.5 miles on the Schuylkill River, and it handles most of the general cargo of the Delaware River Port.

The history of the Delaware dates back to the Lenni-Lenape Indians whose tents originally lined its banks. They fished, trapped and traded for their existence on what they called the Poutaxat, the Makiriskitton, Makarish-Kisken and Whitituck. It was not until the year 1610 that the Delaware River and Bay received its present name. Ironically enough, the man for whom it was named never saw it. He was Baron de la Warr, then Governor of Virginia, who in 1610 saw the need for new food sources for the starving Virginians. He despatched the Vice Governor, Sir Samuel Argall, to Bermuda in search of food; but heavy storms blew Sir Samuel off his course and he came into what he described as "a very great bay." In accordance with the custom of the time, he named the bay Delaware after his superior, Baron de la Warr.

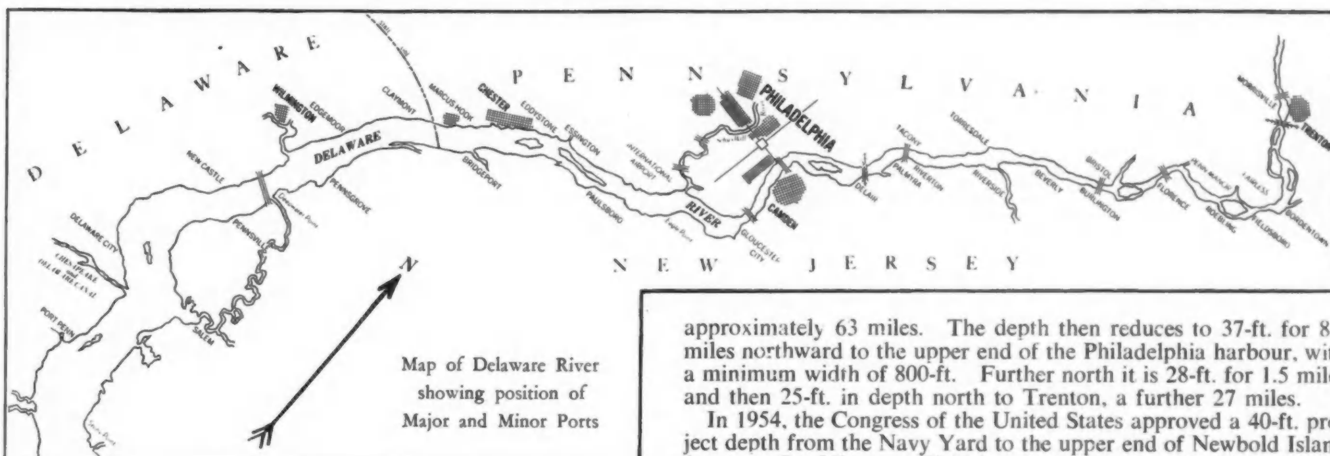
The name of William Penn has long been attached to the Delaware as the first settler. History manuals, however, record that Penn was not the first settler nor was Philadelphia the first port. In the year 1623, or 23 years before Penn was born, Dutch soldiers built a fort at the present site of Gloucester, New Jersey, and in 1638, the Swedes built Fort Christina near present day Wilmington, Delaware.

William Penn sailed up the Delaware in 1682 to the site of present day Philadelphia where he chose a place he described as "high, dry and healthy . . . where the most ships may best ride . . . to load and unload . . . without boating and litering." Penn made peace with the Indians and laid out his city in geometric design and began life based upon his "Holy Experiment." Before docking his vessel, "Welcome," at Philadelphia, however, Penn had anchored at New Castle, Delaware, for his first landing on American soil. He tried to set up a friendly provincial government but was told his new province would be land-locked if the colonies on either side of the River or Bay were hostile. He petitioned the Crown for the land on the west side of the River below his province and this was conveyed to him in March, 1682. Thus it was that Penn gained control of The Three Lower Counties—now the State of Delaware—and granted them a place in his "Frame of Government." This was not found satisfactory because of time and distance in attending general assembly meetings, and in 1704 Penn consented to demands for a General Assembly for the Three Lower Counties. Delaware became a state on December 7, 1787, and was the first state to ratify the new Federal Constitution.

For more than a century after Penn's arrival at Philadelphia, the area was an important logging community; but as the forests along the Delaware's banks began to disappear, logging was followed by farming and new communities sprang up as a new nation was in the making. Light industry and trade eventually supplanted the previous way of life, and Philadelphia and the Delaware River were the centre of much of the Revolutionary War days' activities. As the War came to a close, such men as Stephen Girard made the Port of Philadelphia and its ships known to the Seven Seas.

Port Facilities.

The Delaware has a river channel depth of 40-ft. from deepwater in Delaware Bay to the Philadelphia Naval Base, a distance of approximately 63 miles. The depth then reduces to 37-ft. for 8.5 miles northward to the upper end of the Philadelphia harbour, with a minimum width of 800-ft. Further north it is 28-ft. for 1.5 miles and then 25-ft. in depth north to Trenton, a further 27 miles.



Map of Delaware River showing position of Major and Minor Ports

In 1954, the Congress of the United States approved a 40-ft. project depth from the Navy Yard to the upper end of Newbold Island (opposite Roebling and Fieldsborro—see plan) and a 35-ft. channel from that point, to Trenton. Work has just begun on the first phase of the project and it is expected the entire work will last over several years and involve an expenditure exceeding $100,000,000.

The river is navigable throughout the entire year and is tidal to Trenton. The mean tidal range is 4.4-ft. at the Delaware Cape; 5.3-ft. at Philadelphia and Camden, and 5.75-ft. at Trenton. The extreme range in the Port varies about 2-ft. below to 9.5-ft. above mean low water under the influence of heavy and long continued winds. Tidal currents never exceed three miles an hour.

Philadelphia.

The City of Philadelphia owns 14 general cargo piers which are commercially operated by private shipping interests. These facilities represent an investment of $50,000,000 and are controlled and administered by the Division of Port Operations, Department of Commerce of the City. A long-range modernisation programme has been undertaken by the City resulting in extensive pier improvement. Pier 80 South, completed in 1951, is recognised as one of the most modern of pier facilities.

A contract has been let to convert two City piers, 38 and 40

Ports of the Delaware River—continued

South, into one large marine terminal. This improvement is to cost $2,300,000, with the City appropriating $1,400,000 and the Pennsylvania Department of Forests and Waters the remaining $900,000.

These two piers are now finger piers 551-ft. long and 620-ft. wide. They will be joined to accommodate three ocean-going vessels, one each to the north and south finger sides and another at the marginal front. There will be double rail tracks on each apron and the centre, which is now water, will be filled in and concrete decking installed to serve motor-trucks with tailgate level service and full turn-round. The work is expected to be completed in early 1957. It will increase the general cargo handling capacity of the two piers from 190,000 to 332,500 tons a year.

One of the largest integrated marine terminals along the Atlantic Coast is Port Richmond, a 225-acre, mile-long facility for the handling of all types of cargo. Owned by the Reading Company, Port Richmond is located at the north end of the main Philadelphia harbour and has a rail storage yard with 85 miles of tracks and a capacity of 5,600 cars. It has 10 piers with 17 berths for large cargo vessels. These include two coal piers, an ore pier, a grain elevator with a 2,500,000 bushel capacity with a pier and grain gallery and six general merchandise piers, four of them equipped with transit sheds and warehouses. Two open piers are equipped with travelling gantry cranes with capacities of 10 to 50 tons. There is a stiff-leg derrick on one pier with a capacity of 100 tons. In addition to its Port Richmond facilities, the Reading Company owns Pier 24 and 27 North, general merchandise piers used principally by coastwise and inter-coastal services.

The Pennsylvania Railroad owns and operates pier facilities at three locations in Philadelphia Harbour. The Girard Point Terminal is located on the Schuylkill River just above its confluence with the Delaware. This terminal includes an ore pier, another used principally for china clay, a grain elevator with a 2,225,000 bushel capacity with a pier and grain gallery. Eight vessels can berth at this terminal. At Greenwich Point on the Delaware River just north of the Philadelphia Naval Base, the Pennsylvania Railroad maintains a coal pier with two modern rotary coal dumpers with a capacity of 1,000 tons per hour and a 60-car capacity tipping plant, and bunkering facilities for tugs and small vessels. Also at Greenwich Point is this railroad's ore-handling facility which was placed in operation in 1954. This is the largest and most modern of its kind on tidewater in the United States. It is equipped with four ore-unloading machines and can work two vessels simultaneously and discharge up to 5,600 tons per hour. It is operated by the Pennsylvania Tidewater Dock Company.

The Pennsylvania Railroad also owns and operates a group of general merchandise piers called the Washington Avenue Wharf group in the central harbour area. Pier 82 South, a leased Municipal pier, is equipped with two 25-ton gantry cranes. Four other piers have accommodations for 8 ships.

Piers 96, 98 and 100 South, in the extreme southern section of Philadelphia, are owned by the United States Government and are presently under lease to Philadelphia Piers, Inc., a private terminal operator. Providing 12 deep-water berths, they are regularly served by many steamship lines operating in the foreign trade. Rail tracks on these piers have a capacity of 448 cars. Covered transit and storage space totals 960,000-ft. and open storage of 25 acres is available. Modern construction and convenient pier location make this terminal especially convenient for receipts or shipments by rail or truck. These piers are served by the Pennsylvania Railroad, Reading Company, and the Baltimore & Ohio Railroad.

Marine Terminal, Wilmington, at junction of the Christina and Delaware Rivers.

Municipal Piers 78-80-82 and 84 South Wharves, Philadelphia, with Delaware Avenue running left to right at base of piers. The city of Philadelphia can be seen at upper right.

Camden, N.J.

At Camden, New Jersey, just across the Delaware from Philadelphia, the Camden Marine Terminals are operated by the South Jersey Port Commission, a public agency of the State of New Jersey. The concrete marginal wharf is 1,050-ft. long with a wide apron and surface rail tracks to facilitate direct shipside service. Transit cargo sheds and warehouses provide 207,000 square feet of enclosed storage space. Eighteen acres of open storage and two covered lumber storage sheds make the terminal ideal as a lumber facility. These terminals are equipped with two gantry cranes for the handling of bulk and heavy commodities at shipside. Complete bagging equipment for bulk materials is also available. The terminals are served by the Pennsylvania Railroad and the Pennsylvania-Reading Seashore Lines.

Wilmington, Delaware.

On the Christina River near its juncture with the Delaware River at Wilmington, Delaware, the Board of Harbour Commissioners of the City of Wilmington operates the Wilmington Marine Terminal. This terminal has a marginal wharf 2,060-ft. long, providing berthing space for four ships. The channel in the Christina is 30-ft. deep from the Delaware to the marine terminal. The terminal is well equipped with three travelling gantry cranes and other mecha-

Ports of the Delaware River—continued

nised handling equipment. There are 336,000 square feet of covered storage space and approximately 100 acres of open storage space.

Chester.

Midway between Philadelphia and Wilmington at Chester, Pennsylvania, the Chester Tidewater Terminal, Inc. owns and operates an open pier. This terminal, in addition to its pier, has 100 acres of land and buildings for manufacturing and storage.

Trenton.

Up the river from Philadelphia, at Trenton, New Jersey, the head of navigation, the City of Trenton owns the Trenton Marine Terminal. This terminal, operated by Trenton Marine Terminals, Inc., has a bulkhead wharf 1,200-ft. long, approximately 80,000 square feet of covered storage space, and an open storage area of 700,000 square feet.

The Delaware River Port Area is served by approximately 83 scheduled steamship lines which link the Port directly with 233 ports in approximately 75 foreign countries or territories. There are also 11 domestic steamship lines providing regular service between the Port of Philadelphia and the ports along the South Atlantic, Gulf and West Coasts. These regular line operations are in addition to the numerous special purpose vessels which, under private ownership or charter, transport such cargoes as oil, ores, grain, and coal to and from the Port Area.

Port Administration of the Delaware River Ports.

The administration of the Delaware River Port is a joint enterprise of many Federal, State, and Municipal agencies, each operating within a special sphere of activity and control.

The Delaware River Port Authority, as the successor of the Delaware River Joint Commission, was created on July 17, 1952, by a compact between the two states, with the consent of Congress, as a self-sustaining, public corporate instrumentality of the Commonwealth of Pennsylvania and the State of New Jersey. It is composed of 16 commissioners, eight resident voters of each of the states who serve without compensation. The Auditor-General and State Treasurer of Pennsylvania are members ex-officio.

The Authority operates and maintains the Benjamin Franklin Bridge between central Philadelphia, Pa., and Camden, N.J., and is currently constructing a new vehicular suspension bridge across the Delaware River connecting South Philadelphia and Gloucester City, N.J. This bridge, costing $90,000,000 will be named the Walt Whitman Bridge and will be opened to traffic in 1957.

The Authority has no power of taxation nor can it pledge the credit of either state in any of its undertakings. It is permitted, however, to pool the revenues from its river crossings to other construction undertakings and for the development and improvement of the Port District as well as promotion of the Delaware River as a highway of commerce.

Its legislation also charges the Authority with the co-operation with all other bodies interested in, or affected by the promotion, development, or use of the Delaware River and the Port District; the study and making of recommendations for the improvement of terminal and other facilities necessary for the promotion of commerce; institution through its counsel, or such other counsel as it shall designate, or intervention in, any litigation involving rates, preferences, rebates or other matters vital to the interest of the Port District; and the performance of such other functions which may be of mutual benefit to the Commonwealth of Pennsylvania and the State of New Jersey, insofar as concerns the development and promotion of the Port District and the use of its facilities by commercial vessels.

Although the Authority does not at present own or operate any marine terminal facilities, the Port Development Department of the Authority is engaged in developing and promoting the commerce of the Port Area. This Department maintains a Traffic Bureau, a Statistics and Research Bureau, and a Solicitation Bureau with field offices in New York City, Chicago, Illinois, and Pittsburgh, Pennsylvania.

The Federal agencies with responsibilities in the administration of the Delaware River Port include the Corps of Engineers, Department of the Army, and the United States Coast Guard, Department of the Treasury. The Corps of Engineers, under the direction of the Secretary of the Army, is responsible for the improvement and maintenance of rivers, harbours, connecting channels and other waterways. The Delaware River Port Area is under the jurisdiction of the District Engineer, Philadelphia District, of the Corps of Engineers. His responsibilities include the dredging and maintenance of channel projects as authorised by Congress, recommendations for the establishment of bulkhead and pierhead lines and the granting of permits for improvement and construction work beyond such lines. The Coast Guard, through the Captain of the Port, is responsible for port security and the enforcement of rules and regulations governing the anchorage and

Girard Point Terminal of the Pennsylvania Railroad, located on Schuylkill River, Philadelphia. The grain elevator in the centre of picture has a capacity of 2,225,000 bushels.

Ports of the Delaware River—continued

movement of vessels on the river, maintaining aids to navigation, supervision of explosives, and inspection of vessels and equipment.

The control of the Pennsylvania waterfront is vested in the Navigation Commission for the Delaware River of the Commonwealth of Pennsylvania and in the Division of Port Operations, Department of Commerce, City of Philadelphia. The Division of Port Operations has supervision over the waterfront within the limits of the City of Philadelphia, while the Navigation Commission for the Delaware River has jurisdiction over the remainder of the Pennsylvania Port Area.

The riparian laws of New Jersey are administered by the Bureau of Navigation, Department of Conservation and Economic Development of the State of New Jersey. Another New Jersey state agency, the South Jersey Port Commission, has jurisdiction over a Port District which includes the seven counties of New Jersey bordering on the navigable portion of the Delaware River. The Camden Marine Terminals at Camden, New Jersey, are owned and operated by this Commission.

The operation of the Marine Terminal at the Port of Wilmington, Delaware, is administered by the Board of Harbour Commissioners, a municipal corporation created by an act of the State Legislature to act for the mayor and council of Wilmington.

In addition to the agencies which control and administer the waterways and waterfront of the Ports of the Delaware, there are many other Federal and local agencies and organisations which either exercise some jurisdiction over waterborne commerce in the Port or are engaged in the work of developing and promoting aspects of the area's maritime activities. Philadelphia and other Ports on the Delaware are well served by local offices of these Federal and regional agencies.

Waterfront Industries of the Delaware River Ports.

More than 80 per cent. of the tonnage of the Delaware River Ports is handled over piers owned and operated by private industrial firms. The area's location and terrain have been vital factors contributing to its development as an outstanding industrial centre. The land along its banks is generally level, lending itself ideally to industrial construction. Parallel to the River is a complete range of transportation facilities—major rail lines, truck services, air lines and modern superhighways linked by modern bridges, and the River which furnished the water highway also provides fresh water for industrial use.

The Delaware River Port Area has the largest network of oil refineries on the East Coast of the United States. The seven refineries, Atlantic and Gulf in Philadelphia; Sinclair and Sun in Marcus Hook, Pennsylvania, Socony Mobil in Paulsboro, New Jersey; Tide Water at Delaware City, Delaware; and the Texas Company at Claymont, Delaware, and Westville, New Jersey, import more crude petroleum than all other ports of the United States combined. They have a productive capacity of more than 700,000 barrels a day. One of the main reasons for the oil industry's choice of the Delaware River for location of refineries is the advantage of abundant quantities of fresh water which is so vital to oil refining processes. One recently constructed plant alone is pumping 275,000 gallons of river water a minute through its cooling system and back into the river, the only effect on the water being to warm it slightly. This same plant has a treatment system for well water large enough to serve a city of 200,000 persons.

Chemical manufacturing is another major industry of the Delaware River Port area. Wilmington has earned the title, "Chemical Capital of the World." Chemical plants are not limited to Wilmington, however, but are found throughout the entire region. They are located along the riverfront in Pennsylvania, New Jersey, and Delaware, maintaining piers and wharves for the receipt of raw materials and the shipment of finished products.

Steel production also has become one of the Delaware River's important industries. At Fairless, Pennsylvania, the United States Steel Corporation has built a $450,000,000 integrated mill which has a 1,000-ft. dock for the handling of import iron ore from Venezuela and other ore producing countries of the world. Other steel plants in the immediate area and in the interior receive ore through the ore-handling facilities of the Pennsylvania Railroad and The Reading Company.

The waterfront at Philadelphia is the home of two large sugar refineries, the Franklin Sugar Refinery of the American Sugar Refining Company and the Pennsylvania Sugar Division of the National Sugar Refining Company. Each maintains its own pier facilities for the receipt of raw sugar and other waterborne cargo. Approximately a million tons of sugar are handled at these piers annually.

The Delaware River Port Area is served by four electric companies, each of which has one or more steam generating plants on the Delaware River, and they are so interconnected that an un-

Southern portion of central harbour area of Philadelphia. Camden, New Jersey, is on the right and the Benjamin Franklin Bridge spans the Delaware River at upper right.

Ports of the Delaware River—continued

limited supply of power is available to meet peak or emergency needs of the entire Port Area.

The Delaware River has long been known as the "Clyde of America" because of its shipbuilding activities since Colonial times. One of the best known shipbuilding concerns is the New

New P.B.R. Ore Pier, Greenwich Point, Philadelphia, showing two of the four ore machines.

York Shipbuilding Corporation at Camden, New Jersey, where great ships such as the passenger liners "Manhattan" and "Washington," the aircraft carrier "Saratoga," and the U.S.S. "South Dakota," that won world renown in World War II as Battleship X, were built. The site consists of about 160 acres and extends along the waterfront for nearly a mile. The Company was founded in 1899 and since that time has built more than 600 vessels.

At the confluence of the Delaware and Schuylkill Rivers is the Philadelphia Naval Base and the Shipyard where many of the U.S. Navy's outstanding fighting ships, including the Battleships "Washington," "New Jersey," and "Wisconsin," were built. This yard has more than 150 years of Naval tradition and covers an area of 440 acres with 7,000-ft. of waterfront wharfage. The facilities include two shipways, two marine railways, three graving docks for repairs and two super graving docks for building ships which are rated among the largest in the world. The yard has a crane capable of lifting 350 tons.

A third large shipbuilding facility on the Delaware is the Sun Shipbuilding and Drydock Company at Chester, Pennsylvania. Founded in 1916, the prime interest of this yard has been the construction of merchant vessels with emphasis placed on tanker work. Sun Ship engineers designed the T-2 type tanker, which became famous during the Second World War. During this war, the shipyard grew until there were 28 slipways, 10 wet basins, shops of all kinds, huge cranes and other large equipment stretching for almost two and one-half miles along the River. Since its founding, Sun Ship has built 537 vessels, repaired 13,000, of which over 5,000 have been raised on two floating drydocks. Since the end of the war, this yard's output has included 15 supertankers of 600-ft. or more in length.

Several other smaller shipbuilding and ship repair yards are engaged on many contracts for both government and private ship operators.

Commerce of the Delaware River Ports.

Since World War II, commerce of the Delaware River Ports has shown a very rapid rate of growth. In 1948, the total tonnage of the Ports was 57,010,990 short tons. By 1955, official figures show 86,858,624 tons; and it is estimated that the 1956 total will be in excess of 90,000,000 tons. Foreign commerce has shown the most rapid increase since the War. In 1948, the Ports handled 16,576,215 short tons of exports and imports. In 1955, the total had reached 39,761,738 tons, and is expected to be between 40 and 45 million tons in 1956.

The Delaware River Port is an industrial port, and the greatest tonnage increases have been made in the importation of raw materials to supply this industrial complex. Imports for 1955 totalled 36,150,777 short tons. Crude petroleum imports accounted for over 24,000,000 tons of this figure, while ores (iron, chrome, and manganese) accounted for another 8,000,000 tons. Other bulk commodity imports included sugar, molasses, gypsum, clays and earths, and fluorspar. General cargo imports amounted to approximately 1,600,000 tons in 1955.

Export tonnage for 1955 was 3,610,961 short tons, of which approximately 50 per cent. was general cargo and 50 per cent. bulk cargo, consisting chiefly of anthracite coal and grain.

New Zealand Dock Labour

Report of Waterfront Industry Commission for 1956

In the course of a general survey of the year ended 31st March, 1956, the Annual Report of the New Zealand Waterfront Industry Commission states that while the speeds of work performed on the waterfront during the year ending 31st March, 1956, are still substantially better than prior to the 1951 strike, there has been a slight reduction in the speeds of work at most ports as compared with last year. It is pleasing to record, however, another year of peace on the waterfront free of any major disputes involving stoppages of work. From a total of 15,795,000 man-hours worked, the only industrial dispute involving a stoppage of work was a loss of 240 man-hours for three gangs employed on a vessel at Wellington; a loss of 13,025 man-hours at Auckland through two unauthorised stop-work meetings, and a loss of 2,453 man-hours at Bluff when an unauthorised holiday was taken by the men at the time of the Southland Centennial Celebrations.

The average number of days spent on the New Zealand coast by overseas refrigerated vessels discharging and loading increased from 49.39 days in 1954-55 to 54.77 days in 1955-56. For vessels which only loaded at New Zealand ports the average time spent on the coast increased from 26.4 days in 1954-55 to 32.48 days in 1955-56. The increased time taken in turn-round of overseas refrigerated vessels during the year ending 31st March, 1956, was due to an increase in the tons of cargo carried by each vessel, an increase in the number of ports visited by each vessel, involving increased steaming time, and the slight reduction in speeds of work.

The total cargo discharged and loaded at New Zealand ports for the year ending 31st March, 1956, was 11,268,000 tons, as compared with 10,435,000 tons in 1954-55, an increase of 833,000 tons. The increase in trade resulted in an increase in the average hours worked and average wage paid to waterside workers and a reduction in daily and weekly guaranteed wage payments. The total amount of bonuses paid out under the Commission's co-operative contracting system reached a record figure of £994,668, as compared with £929,760 distributed in 1954-55. There was a slight reduction in the rate from 1s. 9.75d. per hour in 1954-55 to 1s. 9.47d. per hour in 1955-56.

The first General Principal Order of the Waterfront Industry Tribunal prescribing wages and conditions of employment expired on 31st August, 1954, and, following negotiations between employers' and workers' organisations during the current year, a substantial measure of agreement was reached. The main matters in dispute not agreed to by the parties were claims by the workers for an increase of 9d. per hour in the basic wage rate and for a subsidised superannuation or pension scheme for waterside workers. These matters were referred to the Tribunal which made a new General Principal Order for a period of two years from 22nd August, 1955. The Tribunal awarded an increase of 3d. per hour, making the basic rate 5s. 3d. per hour, and stated that it was thoroughly appreciative of the improved records of work on the waterfront during recent years and had taken this into account in making its new order. The Tribunal considered, however, that in the absence of agreement it would be undesirable for it to impose on the industry a subsidised superannuation or pension scheme and suggested that the parties carry out further

New Zealand Dock Labour—continued

negotiations with a view to agreement being reached for the introduction of a scheme on a voluntary basis.

In the Commission's annual report for last year reference was made to some deterioration in industrial relations between employers and workers. It can now be reported that good relations have been re-established at all ports and this is no doubt due to completion of negotiations between the parties and the issue by the Tribunal of its second General Principal Order prescribing wages and conditions of employment in the industry. Harmonious relations exist between the Commission and both employers' and workers' organisations.

Data regarding rates of work and stevedoring costs clearly indicate that there has been some reduction in the rate of cargo handling at most ports during the year under review and at the same time there has been an increase in non-productive time, i.e. time taken in handling hatches, gear, awaiting cargo, weather delays, etc. While the work at present may be considered to be reasonably satisfactory, there is room for improvement and this can be brought about by the full co-operation and goodwill of employers and workers.

The Commission in its annual reports for the past two years has drawn attention to the responsibility of shipping companies and other employers to exercise adequate and continuing supervision to ensure that men work the full hours for which they are paid. Last year's report stated that there had been a tendency at some ports for men to be allowed to start late and finish early and if this was allowed to drift it would result in a reduction in the cargo handled per day and a deterioration in the turn-round of shipping. The Commission's records and reports received from its branch offices indicate that this drift is occurring. The attention of shipping companies has been drawn to the position and the Commission has also again recommended to the New Zealand Port Employers' Association, as was done in 1954, that consideration should be given to the introduction of a training scheme for foremen. The efficiency of this vital industry largely depends on the quality of supervision exercised by employers, and if the efficiency of the industry is to be maintained and improved it is imperative that shipping companies and other employers carry out their responsibilities in this connection.

The further increase this year in non-productive time stresses the desirability of giving effect to the Commission's previous recommendations of incorporating in the contract rates the time taken in handling hatches, rigging gear, weather delays, etc., and so provide an incentive to the workers to reduce this non-productive time when cargo is not being worked. Employers' and workers' representatives were engaged during the past year in negotiations in connection with the revision of the Tribunal's General Principal Order and supplementary orders as to special conditions of work at each port. These have been finished and it should now be possible for the parties to carry out, with the Commission's assistance, a comprehensive revision of contract rates and the inclusion in the revised rates of non-productive or non-cargo working time.

The permanent and casual unions at the Port of Wellington amalgamated as from 1st August, 1955, under the name of the Wellington Amalgamated Watersiders' Industrial Union of Workers. The Tribunal continued the then existing conditions of employment to the permanent and casual sections of bureau register. The workers in permanent employment, at a ballot conducted in February, 1956, voted in favour of casual employment by a two to one majority. Following an application to the Tribunal and further negotiations between the employers and union, the Tribunal in August, 1956, issued an order which gave effect to an agreement reached between the parties and provided for all registered workers to be placed on casual employment, as applies at other ports, except 36 men who are permanently employed by the Anchor Shipping and Foundry Co. Ltd. Provision was also made whereby any other shipping company could make application to the Tribunal to employ permanent workers, the decision to rest with the Tribunal as to whether such an application would be approved.

This decision of the Wellington dockers will be found surprising by many experienced port officials, who know of the strong desire in many ports of the world for decasualisation. It is useful, therefore, to examine the implications of the terms "permanent" and "casual," for they may have different meanings in different ports.

A primary aim of most port workers' unions is security of employment for their members. An arrangement, such as the British Dock Labour Scheme, which guarantees a minimum wage, is said to give that—but the big majority of stevedores and dockers in British ports would not agree that living on their weekly guarantee was what they meant by security. To accept permanent employment by one labour employer, however, is a different matter. In normal circumstances, the employee would expect to earn at least the average of all the workers in his own port. To some men, however, permanency is distasteful, since as freelances they always have the opportunity of trying to get the best paying or the most congenial jobs. It is imagined that this is the kind of decision the Wellington workers made—and it will probably satisfy many of them whilst there is normally work for all. It is most doubtful, however, whether such an arrangement benefits the work of a port, although those in favour of it often argue that it is "democratic." As already stated, the Commission's report emphasises the need for high-quality supervision. When foremen have to deal with different personnel each day, i.e. with men who have no roots in any particular employing organisation, the responsibilities and difficulties of the task of supervision are considerably increased.

Dock Labour in Japan

In view of the controversy which greeted the publication in June, 1956, of the Devlin Report on the working of the National Dock Labour Scheme, this Journal has, over the past months, printed a number of editorial comments and articles on the problem of dock labour. In the January issue appeared a review of a treatise by Dr. Werner Klugman on "The Hamburg Port Worker." On the same primary subject is an article on "Dock Labour in Japan" by J. F. Soares, Director of the Asian Office of the International Transport Workers' Federation. This article, which appeared in a recent issue of the I.T.F. Journal, fulfilled a promise by the General Secretary of the I.T.F. when he summed up the discussions at the concluding session of the I.T.F. Asian Transport Workers' Conference in Tokio in April, 1955. "We will denounce in the I.T.F. publication," he said, "the scandal that dockers in Japan are still compelled to work twelve hours a day. We will also raise the question in the I.L.O."

Mr. Soares begins his article, which, of course, is written from the Union point of view, by clarifying the position of the docker in Japanese law. He states that unlike most countries in the West and also some in the East, working conditions of dockers in Japan are not determined by any specific statutory regulations. The dockers are considered a part of the country's labour force and are therefore subject only to the provisions of the generally applied Labour Standards Law.

This Law, which is designated Law No. 49 of 7 April, 1947, covers many types of "enterprises"—a fluid term used to denote any and every type of business, stevedoring being one. It is therefore not surprising that, at least in so far as the dockers are concerned, the Law is honoured more in the breach than in the observance and that its "flexibility" permits of its violation by some 1,114 stevedoring "enterprises" in the country and by the many labour bosses who control the dock labour force.

True, Article 6 of Law 49 states that "unless permitted and based on the Law, no person shall obtain profit from an occupation of intervening in the employment of others"—a laudable provision but one which is certainly not observed. However (proceeds Mr. Soares) our task in this article will be concerned not so much with the provisions of the Law—which in themselves are excellent—but with their observance in practice and we shall attempt to show that the Japanese docker, than whom there is hardly a more diligent and painstaking worker, receives at the hands of his employers a very raw deal indeed.

There seems to be some doubt as to the number of dockers employed on a regular basis or otherwise in the 87 major and minor ports of Japan. One source holds that the regular and casual dockers available for employment number some 110,000;

Dock Labour in Japan—continued

another that the dock labour force is but 90,000. Whatever the correct figure may be, records show that in the six major ports, viz. Tokyo, Yokohama, Osaka, Kobe, Nagoya, and Shimonoseki, there is regular employment available for only 60,000 dockers, including supervisory staff, barge and tug-men.

Under the prevailing laws any person can register himself for dock work through employment exchanges, called in Japan "Public Employment Security Offices" (PESO). It is therefore to be expected that, in a country where unemployment is rife, persons unaccustomed to dock work register at such employment exchanges and accept employment as "casuals" on terms dictated by the gang bosses, terms which are more often than not much below the average wage levels for dock work. Registration by "casuals" at these employment exchanges thus explains the reason for the large surplus force available for dock work—a factor which militates against both security of employment and guaranteed earnings.

In these circumstances, gang-bosses and stevedoring firms are able to play one group against another and except for a selected group largely in the permanent employ of certain stevedoring concerns, dock labour in Japan is mainly casual labour, dependent for employment on the whims and fancies of gang bosses—parasites who exact from their unwilling victims a percentage of earnings for services rendered.

Vested interests, as can be readily gauged from the above, are deeply concerned to see that no changes in the present system of dock employment are brought about and vehemently oppose any or all schemes of decasualisation. Fear of unemployment, of gang bosses and of stevedoring firms accounts for the fact that barely a fifth of dock labour is at present organised. Nevertheless, the All-Japan Dock Workers' Union continues in its efforts to bring the benefits of unionism to dock labour in Japan in the face of opposition from the vested interests and the deeprooted fears of the workers themselves. The union, supported by Sohyo—the three million strong General Council of Trade Unions of Japan—and the Socialist Party, is at present engaged with legislation for the introduction of decasualisation schemes for dock labour, based on the recommendations of the ILO's Inland Transport Committee. In these efforts, the union, though not an affiliate, is being supported by the ITF and also by the ICFTU. Both of these organisations have addressed themselves to the Ministry of Labour urging that the Bill, which the union is attempting to introduce in the Japanese Diet, be speedily passed into law, thereby helping to provide Japanese dockers with more regulated employment. In the absence of decasualisation schemes, working conditions of dockers in Japan differ very widely not only between ports but often within one port itself. For example, family allowances are not paid to Yokohama dockers, whilst they are in Kobe.

Available for employment in the 87 major and minor ports of Japan are some 110,000 dockers of all categories. Of these, 70,000 can be said to be regulars, 30,000 casuals, and 10,000 unemployable. Employer groups, called "dock work enterprises" total some 1,114 in all the ports. Under the prevailing law any employer can register as an enterprise provided he can prove to have fifteen employees, a feature which, of course, facilitates the emergence of intermediaries, concerned only with exploitation. The permanent work force of these numerous enterprises consists of the regulars. Of these regulars, specialised categories, such as winchmen and gang foremen are a favoured group, receiving at the hands of their employers not only fairly satisfactory employment terms but also generous treatment by way of other benefits inherent in an economy where paternalistic tendencies still exist. The ordinary or casual worker, however, is not so fortunate and the largest body of dockers falls in this category. This type of worker is badly discriminated against, as can be seen from the following figures.

In the port of Kobe, for example, the hourly wage rate for day work is 66 yen for regulars, whilst it is 35 yen for casuals — and nobody denies that these casuals, many of whom have spent ten years and more in their respective callings (but who are unattached to enterprises), are as good workmen as their colleagues in the "regulars" category.

The dockers in Japan work on both a time-rate and a piece-rate basis. Approximately 30 per cent. of the work force, mostly regulars, are on the time-rate system, the remainder being on piece-rate. The casuals, dependent as they are for employment on gang bosses, receive in wages much smaller amounts—even on piece rates—than the regulars. The disparity in rates is as much as forty per cent.—as will be evident from figures already cited—but in the absence of industry-wide collective bargaining or decasualisation schemes, the casuals among the dockers are content to receive the wages paid them rather than be faced with the spectre of unemployment.

The Labour Standards Law provides for an eight-hour working day and a forty-eight-hour week. However, a provision of that law specifically provides that, by ordinance, limits may be exceeded if deemed "essential to avoid inconvenience to the public or the like or where there is other special need." Despite the statutory regulation on the question of working hours, dockers in Japan do in fact work a twelve-hour day and instances are not unknown where some have been required to work for sixteen hours a day. In effect, therefore, a two-shift system operates, whereas, in accordance with the law, a three-shift system would be normal. In Yokohama, dockers change shifts every seven days and in Kobe every five days. In both ports the last-day shift is invariably a twenty-four-hour one.

Overtime under the law is payable at time and a quarter. In the larger ports, casuals are paid at the minimum rate though regulars receive higher payment, a fact which accounts for the gross wage differentials between the two categories of workers. In the smaller ports, overtime working is not common.

Inclusive of overtime, family, and night-work allowances, a regular in the six major ports earns, on an average, 23,000 yen per month (about £23), whilst the casual averages 16,000 yen (about £16). In the small ports earnings are considerably lower, the average being around 14,000 yen (£14) per month. The prevalent basic wage for casuals is 450 yen (9s.) for a twelve-hour day, inclusive of all allowances. Certain specialist grades, such as foremen, winchmen, and flag-men, receive extra allowances from their employers, varying in amount from 5,000 yen (£5) to 8,000 yen (£8) per month.

The All-Japan Dock Workers' Union, known more familiarly by its Japanese title as Zenkowan, was founded in 1946. It has a membership of some 17,000, though collective agreements negotiated by it covers some 20,000 dockers. It has attempted to organise all dockers but has found the going difficult in the face of opposition from employer groups, gang bosses and the dockers themselves, the latter because of a fear of victimisation.

In the face of these difficulties, as already mentioned, Zenkowan is attempting to have legislation enacted to bring about the decasualisation of dock labour, hoping that thereby the evils in the present system of engagement and employment will be eradicated and some sort of security, regularity of employment and guaranteed wages assured to the dock labour force. Yet, even in this attempt, it is meeting with opposition from the same sources. It is known, however, that the Government of Japan is sympathetic to the idea of introducing decasualisation, but is concerned that in so doing it may be called upon to bear the cost of any such schemes, a disquieting feature in the light of the Japanese Government's financial difficulties.

Although, as already stated, the foregoing article emanates from one side of the industry, it is pertinent that once again emphasis is placed on decasualisation. This need is, of course, universally accepted—but it is the means of satisfying it which is being so ardently sought.

In most instances where steps have been taken to give those port workers not regularly employed a guaranteed minimum wage, port operating work has not benefited in the process. Unfortunately, among the noticeable effects of decasualisation has often been a decrease in the keenness and efficiency of those workers whose conditions have been improved—due, it is held in many quarters, to the absence of a normal employer-employee relationship. A satisfactory solution to this particular problem has not yet been found and most methods now being tried are empirical. The British Dock Labour Scheme may have given port workers a guaranteed minimum wage but it has also helped to reduce the worker's sense of responsibility to the organisation engaging **and paying** him. The article would have had an added interest if it had given more information of the **kind** of legislation being introduced to decasualise dock labour in Japan.

Fig. 1. Illumination at Quay level, Birkenhead Graving Docks.

Improved Lighting Facilities at Birkenhead Graving Docks

Brief particulars have been received of work recently carried out by the Mersey Docks and Harbour Board in improving the ship-repairing facilities at their Birkenhead Graving Docks. These docks, which are owned and operated by the Board, are tenanted by private ship-repairing contracting firms who carry out all the work involved in their ship-repairing contracts and meet the Board's charges for the dock facilities provided.

There are three docks in the group, and the new facilities provided comprise considerably improved lighting, quay and shore-to-ship alternating and direct current supplies, welding equipment, piped salt water and compressed air supplies and electrically-operated cranes.

The general level of illumination now provided at quay level and at dock bottom are well illustrated in Figs. 1 and 2 respectively. The lighting intensity at the quay edge is 1.2 foot candles under lamps and 0.4 foot candles midway between lamps. The minimum intensity along the centre of the dock bottom is 0.25 foot candles. It will be seen by reference to the illustrations that a very satisfactory and constant dispersion is obtained by a two-level lighting scheme. Precast concrete lighting columns, of which there are 79 in all, are sited about 85-ft. apart, each having one working or docking light at the top, and one public or walking light lower down the column. The docking lights, which were supplied by AEI Lamp and Lighting Co. Ltd., are mounted 25-ft. above quay level and have 400 watt lamps protected by well glasses carried in open dispersive-type fittings. The public lights are mounted 15-ft. above quay level and have a similar but smaller type of fitting with 125 watt G.E.C. Small Oxford lanterns.

Electricity for use in the actual work of ship repair is supplied at a number of brick-built kiosks adjacent to the quay copes. Three supplies are available:—

460/230 volts direct current, 800 amp cap.
110 volts direct current, 500 amp cap.
400 volts, 3 phase, 50 cycles alternating current, 500 amperes capacity.

The total capacity of the main electrical plant which supplies the kiosks amounts to 1152 KW at 460/230 volts direct current, 165 KW at 110 volts direct current and 1000 KVA at 400 volts, 3 phase, 4 wire, 50 cycles.

In addition six three-phase transformer welding sets are provided by the Board, each set accommodating six welding operators.

The open flush-paved quay areas are suitable for the economic operation of the Contractors' mobile cranes, but in addition the Board have provided two large capacity electric cranes, one in each of the two avenues between the graving docks and arranged to travel the whole length of the docks. Both cranes take a safe load of 15 tons at 85-ft. radius and this covers all positions of the hook up to the centre line of each dock. The cranes operate from the 460/230 volt direct current supply, and connections are made by trailing cable on spring-loaded drums mounted on the crane's structures. The plug boxes which receive the trailing cable can be seen at the left centre of Fig. 1.

Compressed air at 100 lbs. per square inch is supplied for ship repair work at a cost of 6d. per 1000 cubic feet. The supply is piped along the quay edge of each dock to six meter houses whence it is run to the bottom of the dock and has two take-off positions to each metered leg. A total output of 1750 cubic ft./minute at 100 lbs. p.s.i. is provided by three stationary rotary compressors.

Salt water is supplied from the river at a pressure of 80 lbs. p.s.i. with a maximum throughput of 300 gallons per minute. The supply is fed to the bottom of each dock with twelve take-off points. Particulars of the three docks are as follows:—

	Width at Entrance.	Sill above Bay Datum.	Coping at Quoins above Datum.	Length.
No. 1 (East) Dock.	59-ft. 7-in.	5-ft. 11-in.	• 35-ft.	939-ft. 0-in.
No. 2 (Middle) Dock.	48-ft. 7-in.	2-ft. 4-in.	35-ft.	750-ft. 7-in.
No. 3 (West) Dock.	85-ft. 5-in.	3-ft. 4-in.	35-ft.	750-ft. 6-in.

Fig. 2. Illumination at Dock bottom. Birkenhead Graving Docks.

Cargo Handling and Pallet Standardisation

The Trend of Change in Port Operating Work

By E. S. TOOTH

IT was as recently as 1939 that technical circles in many countries was discussing the possible future of palletisation. Was its application going to be limited or was it going to spread throughout industry? At that time, of course, certain large industrial organisations—some of them international—had already planned their handling methods around the fork-lift truck but in most instances their palletised products were carried in their own transport. In the main, too, attention was concentrated on national rather than international traffic, at least in maritime nations, for there were additional complications in taking palletised goods across the sea.

That expansion in the national sphere was occurring quickly is emphasised by the fact that early in 1950 the discussion had turned to the need for pallet standardisation. This implied that palletised loads were by then being offered to common carriers and that the need had arisen for pallets of sizes convenient for stowing in existing conventional road and rail vehicles.

Developments which have since occurred in the United Kingdom are now common knowledge. They have stemmed from the practice of building goods into unit loads, with or without pallets, for handling by fork-lift and pallet trucks. The majority of such loads are palletised; most of the palletised loads are on British Standard pallets. Road and rail vehicles have been altered to meet the requirements of the new traffic; package dimensions are being based on standard pallet sizes; new-type premises are being built so that unit loads can be handled and stowed by the new machines speedily and with no loss of cubic space.

Although similar developments have occurred in the international field, agreement upon international standards for pallets is coming more slowly, mainly because (1) international pallets must be suitable for loading into a variety of types of road and rail vehicles and (2) many nations, or organisations within them, had, at an early stage, adopted pallets of dimensions unsuitable for international use. A point which port operators do not always bear in mind is that through-transit pallets (not dock-tool pallets) must be capable of being handled by pallet truck as well as fork truck, since very often stowing in land conveyance can only be done satisfactorily with the former machine. Pallet standardisation must, therefore, take care of that need and an international standard, whether for large pallets or for small, must cover many technical details of construction besides plan dimensions.

This international work is being undertaken by Technical Committee 51 of the International Organisation for Standardisation, which first met in London in December, 1952. (ISO has 38 member nations and at the time of writing there are 84 technical committees). Although TC/51 found it had a difficult task, its progress has been satisfactory. It held its second meeting, also in London, in June, 1954, its third in Stockholm in June, 1955, and its fourth has just taken place in Paris. Between these meetings, Working Groups appointed by the Committee have met at intervals in London, Amsterdam and Paris.

In 1956, the Committee was constituted as follows: Participating members: Australia, Belgium, Czechoslovakia, Denmark, Finland, France, Germany, Netherlands, Norway, Poland, Sweden, Switzerland, United Kingdom and U.S.S.R. Observer members: Austria, Bulgaria, Chile, Hungary, India, Italy, Japan, Mexico, New Zealand, Portugal, Roumania, Spain, Turkey, U.S.A., Union of South Africa and Yugoslavia. The secretariat is held by the United Kingdom (British Standards Institution). Interested organisations, most of which sent representatives to the meeting as observers (without the right to vote) were: Economic Commission for Europe, Food and Agriculture Organisation of the United Nations, International Cargo Handling Co-ordination Association, International Chamber of Commerce, International Container Bureau, International Labour Office and the International Union of Railways.

The work done prior to the Paris meeting is given in the following summary. Few of the decisions upon which it is based were reached easily.

(a) The nominal plan sizes of flat pallets for general purposes shall be:

32 x 48-in. (800 x 1200 mm.)
40 x 48-in. (1000 x 1200 mm.)
32 x 40-in. (800 x 1000 mm.)

(b) The following tolerances shall apply to the dimensions given in (a):

Effective plan dimensions	Max.	Min.
48 in.	+0 in.	$-\frac{3}{4}$ in.
1200 mm.	+20 mm.	−0 mm.
40 in.	+0 in.	$-\frac{5}{8}$ in.
1000 mm.	+16 mm.	−0 mm.
32 in.	+0 in.	$-\frac{1}{2}$ in.
800 mm.	+15 mm.	−0 mm.

These tolerances are to be regarded as extreme limits within which each member body will fix its own manufacturing tolerances.

(c) The pallets specified in (a) shall be so constructed as to permit the entry of forks or fingers of lifting trucks, preferably from any side, but at least from two opposite sides.

(d) The distance from the underside of the top deck to the ground shall be 5-in. (127 mm.) maximum, and the free height for the entry of forks or fingers, from any side, shall be $3\frac{7}{8}$-in. (99 mm.) minimum.

(e) The area of the bottom deck of a double-decked pallet shall be not less than 40 per cent. of the area of the top deck.

(f) The minimum openings in the bottom decks of 2-way and 4-way entry pallets which shall be provided to allow the passage of the wheels of a hand-operated or power-operated pallet truck shall be those indicated by the continuous lines on the attached:

Fig. 1 for 32 x 48-in. (800 x 1200 mm.) pallets
Fig. 2 for 40 x 48-in. (1000 x 1200 mm.) pallets
Fig. 3 for 32 x 40-in. (800 x 1000 mm.) pallets

However, if the construction will permit, it is strongly recommended that in Fig. 1 and Fig. 2:

(i) the minmum openings provided should be those indicated by the dotted lines on the drawings;

(ii) the minimum dimension of 30-in. (760 mm.) shall be increased to 32-in. (800 mm.)

(g) The members of the bottom deck of a pallet shall be chamfered on each side of the top face in the following way.

(i) the angle between the chamfered surface and the horizontal shall be $40° \pm 5°$.

(ii) the height of the vertical face of the member shall be $\frac{1}{2}$-in. $\pm\frac{1}{8}$-in. (10 mm. ± 5 mm.).

This recommendation shall apply to a pallet made of any material when the thickness of the member concerned exceeds $\frac{3}{8}$-in. (10 mm.).

The evolution of the throughout movement method has preceeded concurrently with the work of the Committee and to suit international needs, industrial organisations have altered not only their pallets but also their road and rail vehicles, their packaging arrangements and their premises and plant. The pallet exchange system, inaugurated in Europe by the Swiss Federal Railways, has now been introduced in other countries. France is the latest recruit. This system, of course, obviates the need to return pallets empty but all who join the scheme must use only standard pallets.

Since one of the more important items on the Paris agenda concerned the standardisation of large pallets, it will be of interest here to examine traffic at present going across the seas. An inspection of the dockside premises of many of the major ports of the world

Cargo Handling and Pallet Standardisation—continued

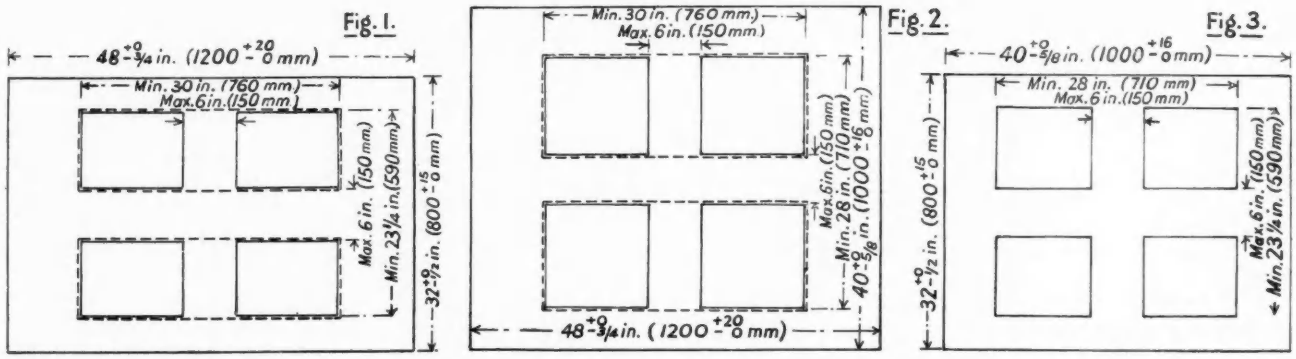


Fig. 1 (left). Minimum openings for pallet truck wheels in bottom deck of 2-way and 4-way 32-in. x 48-in. (800 mm. x 1200 mm.) pallets. Fig. 2 (centre) for 40-in. x 48-in. (1000 mm. x 1200 mm.) pallets and Fig. 3 (right) for 32-in. x 40-in. (800 mm. x 1000 mm.) pallets.

will show that there is an increasing proportion of unit load traffic. Among the palletised commodities are steel plates, crates of hardboard (Fig. 4), bales of cotton and woodpulp, cases of beer and wine, boxes of fish, sheet tin, cartons of canned goods and other provisions, and bags of fertiliser. The variety and quantity of such consignments is increasing steadily. Most loads are built on small pallets (maximum dimension 48-in.) because the land-transport factor has been considered so important. Many shipping interests, however, have maintained that, since the capacity of modern cranes and ships' derricks is at least three tons, a large pallet should be included in the standard.

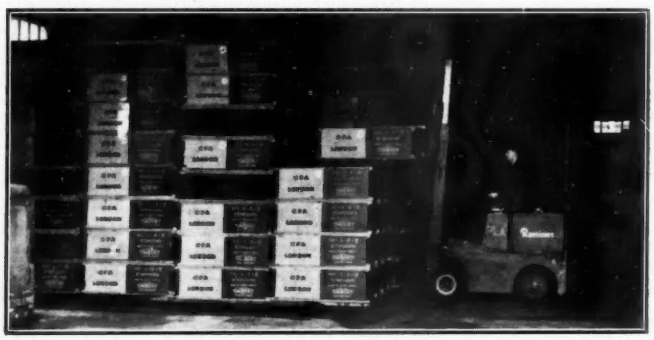
Pallets of large plan sizes, viz. 48 x 64-in. and 48 x 72-in., had already been recommended for standardisation at Stockholm in 1955. This was by a majority vote, however, because, among the nations represented, there were conflicting opinions. One was that a large pallet should be standardised so that, with loads up to the capacity of modern cranes, loading and discharging ships could be done more speedily; another that such a pallet would be too cumbersome for quick and economic handling in road and rail vehicles. A third opinion was that to formulate a standard for a large pallet was at this stage premature because (1) changes are at present being made in ship design to enable mechanical appliances to be employed in ships' holds and (2) the attitude of shipowners to the utilisation of freight space by pallets had not yet mellowed. Dock-tool pallets are, of course, outside the scope of the Committee's work.

The Paris meeting reached no decisions on this matter. At informal discussions, majority opinion was that in view of the steady increase of palletised maritime traffic, a standard for large pallets, covering, of course, all technical details of construction, should be formulated quickly. The matter was referred to a Working Group which, it is hoped, will be able to produce a suitable recommendation for consideration by the next full meeting of the Committee.

Before leaving this subject, it should be mentioned that once docks and harbours are geared to deal with palletised cargo, there is much other traffic which can be handled by fork-lift truck. There are, for example, cylindrical packages such as rolls of linerboard, thin flat packages such as bales of plywood, a huge variety of types of battened cases and also, of course, unit loads built with apertures for forks, such as bricks and metal ingots (Fig. 5). The difficulties which will inevitably arise in the port industry during the stage of transition from traffic in piece goods to traffic in unit load form will therefore be somewhat alleviated because the fork-lift truck is such a versatile machine.

It was found that different points of view were also strongly held when the Committee turned its attention to the formulation of a standard for box and post pallets. Should only the area occupied by the feet or base be standardised? Should the plan dimensions standardised include those of the superstructure, i.e. should they be the outside measurements of the whole article? Should it be the external or the internal measurements which should correspond with the plan dimensions of the flat pallet? Should the height of the box pallet be standardised?

Even on the last question there was not unanimity and it was referred back to the Working Group. There was general agreement, however, that a standard box or post pallet should be capable of supporting not only another similar box pallet but also a standard flat pallet of the same dimensions. Most of the difficulties arose because of the wish to make the pallet suitable for stowing in existing railway wagons as well as for containing an economic load of packages of sizes already standardised to suit flat pallets. The implication is that, if the internal dimensions of box pallets are the same as those of standard flat pallets, the pallet sides must be thin enough not to make the whole article too large for rail transport. Both these conditions can be met if the pallet sides are made of metal but not if they are made of wood—a method favoured, of course, by such as the Scandinavian countries. Finally, the Committee took the view that the land conveyance factor was the controlling one and a recommendation was carried in the following form:



[Photo P.L.A.

Fig. 4. Palletised sheets of hardboard shipped from South Africa to London.

[Photo P.L.A.

Fig. 5. Unit loads of metal ingots, shipped from London to Sweden.

Cargo Handling and Pallet Standardisation—continued

For box pallets and post pallets of sizes 32 x 48-in. (800 x 1200 mm.) and 40 x 48-in. (1000 x 1200 mm.):

(a) the distance from the underside of the top deck to the ground shall be 5-in. (127 mm.) maximum;

(b) the free height for the passage of forks or fingers from any entry shall be $3\frac{7}{8}$-in. (99 mm.) minimum;

(c) there shall be two types of box pallet, which may be with or without a lid;

  (i) box pallets in which the bottom decks comply with the standards for flat pallets.

  (ii) box pallets with feet. The overall plan dimensions of the feet shall not exceed:

    32 x 48-in. (815 x 1220 mm.)
    40 x 48-in. (1016 x 1220 mm.)

(d) for both types (c(i)) and (c(ii)) the maximum overall plan dimensions of the whole pallet shall not exceed:

    32 14/16 x 48 13/16-in. (835 x 1240 mm.)
    40 15/16 x 48 13/16-in. (1040 x 1240 mm.)

(e) the design of a box pallet shall permit a standard box pallet of the same type and dimensions to be stacked on top of it;

(f) the design of a box pallet shall permit a standard flat pallet of the same base dimensions to be stacked on top of it.

Two other matters dealt with at Paris were wing-widths and expendable pallets. The resolution on the former reads "For pallets designed with wings for lifting, the width of wings shall be:

32 x 40-in. (800 x 1000 mm.)
32 x 48-in. (800 x 1200 mm.) } $2\frac{1}{2}$-in. (65 mm.) minimum.
40 x 48-in. (1000 x 1200 mm.)

Expendable pallets have always been a controversial subject, one reason being that a suitable definition has been hard to find. Such pallets may range from a piece of cardboard to a cheap wooden pallet and from a platform made of the same material as the load (e.g. metal concentrates) and thus due for consumption at the same time as the load, to a piece of corrugated iron. Work on this item was brought to at least a temporary conclusion by first agreeing a definition and then settling the essential details of construction. The recommended definition is "An expendable pallet is one which can be considered as non-returnable" and constructional details were covered in a technical recommendation, the gist of which was that the primary dimensions of expendable pallets should be the same as those of the three pallets of sizes mentioned above.

The final question tackled at Paris was the production of a "terminology and definitions" document as an appendix to the international standard. This document has been maturing slowly year by year and at the recent meeting agreement was reached on draft in two languages. On this draft, French and English definitions are placed one on each side of a drawing of the item concerned. The matter has now been referred to a Working Group of representatives of France, U.S.S.R., and the United Kingdom to produce a final recommendation in the three official languages of ISO.

Although the international standard is now taking shape, the Committee still has important work to do. It certainly has to come to a decision about large pallets and to complete its glossary of terminology and definitions in three languages. With regard to expendable pallets, this item will be kept on the working agenda and nations will keep the Committee posted with any developments. Another item of future work is testing. The method of testing is of extreme importance and the Committee was fortunate in seeing experiments in testing standard pallets at the French Packaging Laboratory. It was appreciated, however, that the subject is closely connected with "national safety" and the secretariat will approach the International Labour Organisation for copies of international documents concerning the safety of pallets. These and the national documents provided by member-bodies will be considered by the appropriate Working Group, which will endeavour to draft a recommendation for consideration when the Committee next meets, probably in 1958.

Storm-Surges in British Waters

Further Investigations by Liverpool Observatory and Tidal Institute *

In the Report last year reference was made to the important research work which had been undertaken by the Tidal Institute concerning storm surges in British waters. This work has again dominated the activities of the staff engaged on research, and reports have been given to the Advisory Committee for Oceanographical and Meteorological Research set up by the Ministry of Agriculture, Fisheries and Food.

Much was said last year concerning the important part of the subject which is concerned with the interaction of surge and tide. The work of the Director then in progress has been described in the publication on tides and storm surges in a long uniform gulf[1]. This deals with numerical methods of integration, and special attention has been paid to the development of efficient methods of performing the integrations with a minimum of labour. The technique evolved may be of general use in many types of tidal problems. It was reported last year that the usual law of friction had been replaced by a law in which the frictional force is taken as proportional to a linear combination of velocity and the cube of the velocity, with the constants being chosen so as to agree with velocity and the cube of the velocity, with the constants being chosen so as to agree with the usual square law for the maximum stream in any section under consideration. After the tides in the gulf had been determined the work was repeated for combinations of tide and surge (a) with the surge a maximum near high water, (c) with the maximum of the surge near low water, and (b) and (d) with the maximum of the surge about half tide. The amplitude of the surge was about the same as that of the tide.

The results were rather surprising, for it had been expected that they might have been similar to those obtained for actual tides and surges at Southend. It had been pointed out by the Director in 1929 that at Southend there was a tendency for maximum surges at the mouth of the Thames to occur between the times of normal low water and high water, and the inference had been made that the probability of occurrence of abnormal levels of tide plus surge is lessened by the fact that the maximum surges appeared to be unassociated with high water. The results obtained tend to show that the interactions of tide and surge are not so great as had been expected, and that such a frequency distribution of surges with respect to high water of the tide as is experienced at Southend may be partly attributed to some cause other than that of interaction of tide and surge.

As this matter of the relationship of tide and surge is of very great importance the following table, compiled by Mr. Rossiter and Mr. Lennon, is here given. It gives the percentage frequency of major surges between certain hours related to high water.

	Hours before H.W.						*Hours after H.W.*					
	6-5	5-4	4-3	3-2	2-1	1-0	0-1	1-2	2-3	3-4	4-5	5-6
Southend	11	18	24	20	6	9	2	0	2	2	2	4
Immingham	9	8	6	17	11	8	11	4	4	6	8	9
Liverpool	9	14	12	11	7	6	8	5	5	4	9	10
Avonmouth	7	5	12	11	7	10	15	12	4	4	6	7

A more striking picture of the differences between Southend and the other places is exhibited by the following table.

Hours	6-3	3-0	0-3	3-6	6-0	0-6
Southend	54	35	4	7	89	11
Immingham	23	36	19	22	59	41
Liverpool	35	24	18	23	59	41
Avonmouth	25	27	32	16	52	48

From these results it is evident that no general conclusions can be drawn as to the alleged tendency, as based upon the Southend results, for surges to appear to be more prominent about half tide than they are at high water. There is a little tendency for surges to reach maximum values before high water rather than after high water.

* Extracts from Annual Report for 1956.

[1] "Tides and storm surges in a long uniform gulf" (A. T. Doodson, *Proceedings of the Royal Society*, A, Vol, 237, pp. 325-343, 1956).

Storm-Surges in British Waters—continued

Similar investigations have been made for Liverpool and Avonmouth for the occurrence of large surges in relation to the height of tide. In both cases the largest surge occurred when the tides were nearly at springs. Further investigations will have to be made but the present evidence seems to show that large surges can occur at high water springs.

Returning to the investigation on tide and surge in a long gulf certain results were obtained which are of interest with regard to the use of a linear law of friction. It was found that the coefficient of friction that needs to be used when tidal currents occur is greatly increased by those tidal currents, but that quite valuable results could then be obtained. Another valuable investigation showed how to determine the incoming and outgoing waves from the surge occurring at the mouth of the gulf. This is important because it had been shown that the surge at the mouth is not directly associated with the surge which might be expected from the known winds over the sea; it is the incoming surge which must be related to the meteorological situation.

In the North Sea area, Mr. Rossiter has devised formulae for computing surges at Aberdeen, Tyne Entrance, Immingham and Lowestoft, and these are now being applied by the Flood Warning Organisation. With the exception of Aberdeen, the standard of accuracy for each of the formulae is of the same order. This standard may be best represented by the total coefficient of correlation between observed and computed surge, taken at 6-hourly intervals, for a large number of surges. The coefficients lie between 0.90 and 0.94. Various methods have been used in attempting to determine the constants used in these empirical formulae; extensive partial correlations were found to give little improvement upon straightforward least squares solutions, due to the great intercorrelation between the meteorological variables. The formulae express the surge as a function of the tractive force of the wind (assuming this to be proportional to the square of the velocity) and its direction, at selected points in the North Sea. Allowance has been made for the effect of the curvature of the isobars has upon the wind velocity, the time lag between wind and wind effect, and for external surges. The mode of progression of external surges down the East Coast has been conclusively determined, but little progress has been made in quantitatively forecasting them at Aberdeen. It is principally for this reason that the formula derived for Aberdeen is inferior to the others.

Using the same approach as for the above-mentioned ports, Southend surges were also investigated. The results showed little improvement upon Dr. Corkan's earlier method, and it would appear that least squares solutions of the type referred to mark the limit of accuracy in this direction.

In all the foregoing, the assumption is made that stationary conditions have been reached, or in other words that the water has no inertia. It is known from theory that under certain conditions storm surges may be accompanied by damped oscillations, and this possibility has been exhaustively tested for Aberdeen, Lowestoft and Southend. The main conclusion reached is that for northerly winds any oscillatory motion which may exist is so heavily damped as to be indiscernible among other second-order effects such as interaction between tide and surge. Analysis of residuals at all three ports revealed no lack of transient oscillations of varying periods, but in the period band of 24 to 40 hours, broadly corresponding to the possible periods of longitudinal oscillation of the North Sea, no consistent results could be obtained. For southerly winds, however, there is quite often marked oscillatory motion in the expected period band, and this may be explained in terms of the return of water, previously expelled from the North Sea being geostrophically concentrated on the East Coast. This and other possible sources of discrepancies between observed and computed surge are being examined by regional studies of water movements in the North Sea and English Channel.

Mr. Lennon has done a great deal of work on West Coast surge effects, for which the difficulties are much greater than in the North Sea, due partly to the larger and more complex tides which increase the difficulties of deducing surges from the tidal records, but also due to the special characteristics of the surges themselves which, in their rapid rise and fall, introduce new problems.

Here we are not dealing with a single body of water as in the case of the North Sea but with several channels and gulfs. The importance of this fact becomes apparent early in the investigations when it was seen that different localities showed a certain individuality in their response to surge-generating forces. There are pronounced local effects which are not experienced at other ports and it was clear that the dynamical approach of a single surge changing only slightly in character but progressing along the coast could not be applied with anything like the same success on the East Coast.

Intensive studies carried out both for Avonmouth and Liverpool have stressed the extraordinarily high degree of intercorrelation between thhe meteorological variables; to such an extent, in fact, that it is virtually impossible to discover the dominant surge-generating factor. Most major surges at both ports are associated with a certain ideal meteorological situation involving a slowly moving depression to the W and N of the British Isles which develops a secondary to the S and W of Ireland. The latter moves rapidly across the country to the N and E giving a surge which achieves its maximum at Avonmouth when the depression reaches the latitude of the Tyne; a somewhat lower maximum at Liverpool occurs some 2 to 3 hours later. Other secondaries which take a more northerly route can give a greater peak at Liverpool than at Avonmouth. All theoretical results aimed at isolating surge-generating forces are obscured by these conditions in which the wind veers rapidly from S to N in the space of 12 hours or so. At which point in the sequence the generation of the surge begins, in terms of an actual motion of water, is difficult to determine.

Close attention has been paid to the Bristol Channel since this locality is considered to hold the key to the problem. At Avonmouth several surges are remarkably peaked in form, attaining a considerable height within a very short period. Much of the work has been directed towards devising prediction formulae for this type of surge.

Owing to intercorrelations a change in the number of terms in the prediction formulae produced no apparent change in the quality of the result and in fact, using the same variables, it was possible to have several different sets of coefficients, changing the emphasis from one variable to another, without affecting the ultimate result. These techniques which rely upon the calculation of tractive force from isobaric disposition must necessarily involve an averaging of effects over an area so that it is not surprising that investigations based upon observed winds at the mouth of the Bristol Channel should give a higher degree of correlation and an improvement in prediction for the peaked surges, which must be essentially local in character themselves. Indication is given that a WSW wind at the mouth of the Channel is the one most likely to produce a surge at Avonmouth with a lag of 2 to 3 hours.

The quality of prediction, still rather poor at this stage, has since been improved by the consideration of damped oscillations. A method has been devised whereby such oscillations are first removed from the observed surge; the adjusted values are then considered to represent more faithfully the direct effects of the winds on the water surface. The adjusted surge is used for all correlations and in attempts to determine a prediction formula. In prediction the reverse process must be performed. The application of the formula will give the direct wind effect only and it is necessary to add those decaying oscillations which will be introduced when the predicted wind effects are made to act within the confines of a certain body of water, in this case the Bristol Channel. Inspection of the observed surges suggested a period of 8 hours for these oscillations, a figure which agrees quite well with the theoretical free-period of the Channel, if the boundary is drawn between the Scilly Isles and Pembroke. A damping ratio of only 1.3 : 1 was used. It is interesting to note that the values generally adopted for work in the North Sea are of the order of 30 hours and 6 : 1 respectively.

Even so, certain cases remain which show little response to prediction formulae. These may owe their existence to resonant effects. It has been noted that the secondary depressions, mentioned earlier, do move across the continental shelf area to the South of Ireland at a speed approaching that of a progressive wave in water of this depth. Such matters are difficult to investigate because precise timing of these movements, while essential to the calculations, is impossible to achieve from the data available.

Wave Measurements by Stereo Photogrammetric Methods

By E. A. MISKIN, M.A., B.Sc., Ph.D., A.R.I.C.S., and
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SURFACE water waves are of vital interest in many fields of engineering and oceanography, and a better understanding of the manner in which waves are generated, and the effects subsequently produced on existing or projected engineering structures, depends to a large extent on the accumulation of precise and representative wave measurements. Compared with the magnitude of the problems which confront the harbour or coastal engineer, there is not only an existing deficiency of basic information on wave action that is to be expected or that has already occurred at any specific locality, but there is also little evidence to suggest that this deficiency is likely to be remedied in the immediate future.

Wave action also has considerable bearing on coast erosion, the urgency of which problem has been long recognised. In 1908 Owens and Case wrote "The problem of protecting our coasts from the attack of the sea has now acquired a national importance." Much of the damage to sea defence works in 1953 was a result of wave action, yet the subsequent Conference on the North Sea Floods was remarkable for the almost complete absence of any reference to recorded wave heights. Until such information becomes more readily available, research will be retarded, and the design of coastal engineering works will continue to be more of an art than a science.

It is the object of this paper to refer briefly to the general subject of wave measurement, and to consider in particular the use of stereo photogrammetric methods for this purpose.

In general the information which wave measuring apparatus may be required to supply will vary according to the nature of the problem. An oceanographer concerned with the development or confirmation of theoretical or empirical relationships between the generating wind and the propagation and subsequent decay of the waves as they move away from the generating area, is interested in the whole pattern of the sea surface and the distribution and behaviour of the component wave trains. The coastal engineer is more concerned with the correlation of wave characteristics with beach profile changes, and the establishment of suitable parameters to enable model results to be interpreted in terms of full scale effects. In both cases, however, the degree to which the recording instrument provides information which is representative of the overall wave conditions is of the utmost importance. The inherent disadvantage of many wave measuring devices is that their records are applicable to one point only in the area under consideration. Such instruments include echo sounders, pressure recorders, wave poles, parallel wire gauges, and step resistance devices. An additional serious deficiency of such methods is their inability to record wave direction.

The suitability of any wave recording apparatus may be judged by considering the ideal properties desirable in an instrument designed for that purpose, and suggested requirements are set out below:—

(1) The instrument or instruments should indicate the wave height, length, period, and direction of travel.
(2) The information should be recorded automatically.
(3) The instrument should be free from response or other errors, and be equally sensitive to all waves pertinent to the investigation.
(4) The data obtained should be representative of the conditions prevailing in the whole area under consideration.
(5) The record should be capable of easy analysis.
(6) The method should be independent of visibility.
(7) The apparatus should be reliable, easily maintained and not susceptible to damage or loss.
(8) Speed of installation and portability are desirable.
(9) Initial and running costs should be related to the value of the information required.

A number of papers exist which summarise and compare many of the wave measuring instruments in current use, and the extent to which such instruments fulfil the requirements set out above may be readily inferred by consulting the appropriate references at the end of this paper. The suitability of stereo photogrammetry may likewise be deduced from the description of the method given below. It is relevant to mention, however, that the difficulty of incorporating more than a few of these requirements in any single instrument has to some extent focussed attention on the indirect method of deducing wave characteristics from meteorological data. The results of this approach depend primarily on the accuracy of the weather chart, and on the calculation of the relevant wind velocity. The subsequent determination of the wave length, velocity, and height, is made from diagrams based on empirical relationships between wind and waves, and on certain simplifying assumptions concerning the initial state of the water surface, the distribution of wind strength over the fetch, and the stationary or moving nature of the generating area. If in addition one considers the probability of the existence of wave trains other than those arriving from the main generating area, the reduction in wave energy due to spilling in shallow water, and the effect of refraction or diffraction on wave height, the method is seen to be one which itself depends very largely on comparative records from wave recording instruments.

Stereo Photogrammetry.

Stereo photogrammetry has been used in a number of hydraulic model investigations of different types, and full scale maritime applications include the well known work by Schumacher using cameras mounted on board ship, and the production of hydrographic wave charts of the sea surface by means of a land-based installation on Heligoland. Vertical stereo photographs have also been successfully taken using two aeroplanes with cameras synchronised by means of a radio link. In general, however, few references have been made to the potentialities of the method, and criticisms to the effect that "the analysis is laborious and the method is not useful" may have discouraged further consideration of stereo photogrammetry in many cases where useful information could have been obtained. It is of interest to note that a Russian manual on the use of stereo photogrammetric methods for the measurement of waves on lakes and on the sea, has recently been published.

Basically, photogrammetric measurements depend upon receipt of light from an object at two camera stations which are separated by a known distance. Measurement of the negatives, which record the light rays, in effect re-establishes the direction of the light pencils, and thus fixes in space the object position from which the light emanated. This process is analagous to the estimation of distance in natural binocular vision, but with the added advantage that the measurement of the photographs affords a precise method of fixing both the rays which can be related to other fixed directions. The method can therefore be said to be very similar to the intersection process as carried out by the plane table, but in the case of the photogrammetric techniques the intersections are carried out simultaneously to all points which are within the common field of the two cameras used.

If shutter speeds are made sufficiently high, the simultaneous recording can be considered to be an instantaneous record of occurrences at a particular instant. Such a record of occurrences is of course what is required for an analysis of wave motion, and

Wave Measurements by Stereo Photogrammetric Methods—continued

in the following discussion it is applied specifically to shallow water areas.

Theoretical considerations of photogrammetric techniques make it desirable that the direction of the principal photographic axes should be parallel with the wave crests (or nearly so), for if the direction of the axes is normal to the wave front, unless the cameras are mounted upon elevated platforms, the wave troughs disappear from the line of sight as they fall behind the wave crests. It is preferable therefore for this type of work to have either:

(a) a pier running normal to the coast line;
or (b) platforms built in the sea which are sufficiently stable to hold a camera free from vibration due to the action of the waves;
or (c) very high cliffs, or towers erected parallel with the shore line.

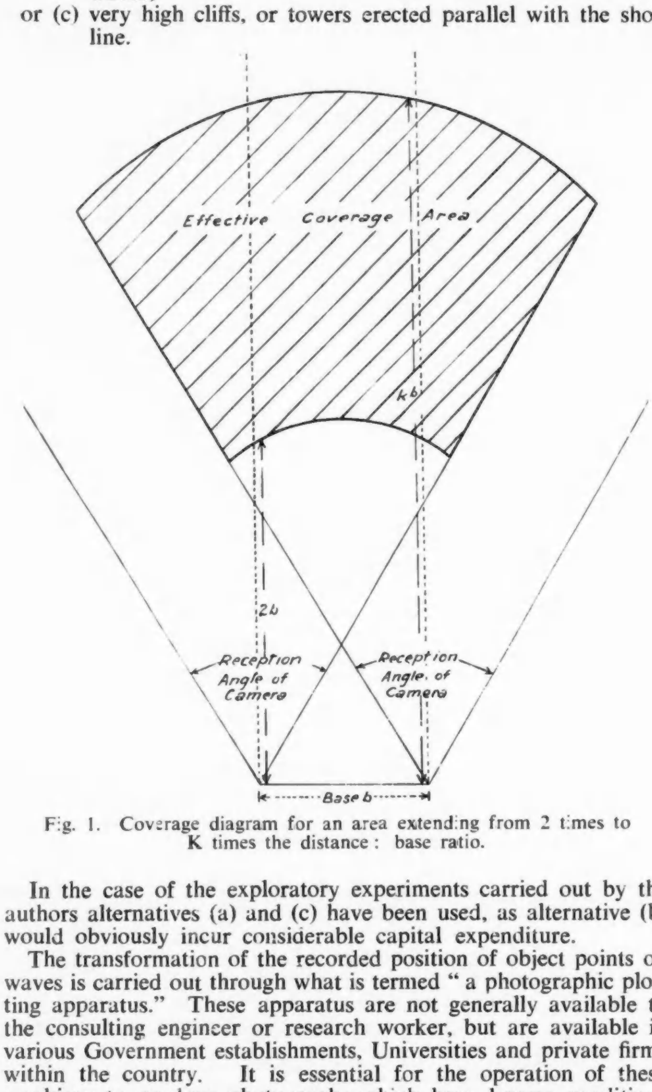

Fig. 1. Coverage diagram for an area extending from 2 times to K times the distance : base ratio.

In the case of the exploratory experiments carried out by the authors alternatives (a) and (c) have been used, as alternative (b) would obviously incur considerable capital expenditure.

The transformation of the recorded position of object points on waves is carried out through what is termed "a photographic plotting apparatus." These apparatus are not generally available to the consulting engineer or research worker, but are available in various Government establishments, Universities and private firms within the country. It is essential for the operation of these machines to produce photographs which have known conditions in-so-far as the inner orientation* elements are concerned. The elements of inner orientation can quite easily be determined by a suitable calibration of the cameras used, provided that the cameras are kept in an unchanged condition after the calibration. This is an essential condition of the process and must be conformed with throughout all subsequent operations.

As well as the elements of inner orientation certain conditions must also be established regarding the outer orientation of the cameras. Sufficient information is normally obtained if the direction of the camera axes relative to the base direction is determined, together with the inclination of the axes from the horizontal. The base is usually defined as the "light-line" joining the two camera perspective centres, and this can easily be measured either by direct optical methods, or by physical methods.

For the simplest case of investigation it is advantageous to have the camera axes horizontal and in a direction normal to the base line. Once again there is no difficulty in setting the axes normal to the base line, but the horizontality of the axes calls for the use of either a bubble mounted upon the camera body, or the use of the visual horizon.

It has been mentioned earlier that the measurement of the photographs depends upon the re-establishment of the orientation of the individual pencils of light. As the measurements are made stereoscopically, the pencils must accord with the conditions of natural binocular vision, namely, that the maximum parallactic displacements shall not exceed 40 mm., and that the minimum displacements shall not be smaller than those which subtend an angle of 15 secs. of arc. These figures are perhaps better related to the base/distance ratio conditions existing at the time of photography, and they will be upheld for all reasonable measurements if the base/distance ratio is not greater than 1/2, and not less than 1/50. From these figures an immediate assessment of the area of sea covered by any one pair of photographs can be made (Fig. 1)†.

One of the greatest difficulties encountered in the method is to distinguish the actual crest or trough of the wave. Naturally photographic definition depends to a great extent upon the contrast in the subject matter: this is low in the case of wave forms, and it is therefore advantageous if the subject contrast can be increased. There are two ways of effecting this:

(1) To photograph during periods in which the obliquity of the sun's rays are such that the maximum contrast is obtained at the cameras between crests and troughs.
(2) By having in the sea a number of suitable coloured markers which may be anchored and therefore remain within a limited area.

In order to make the area covered substantial, it is clear from the conditions of the base/distance ratio given above, that the base must have a quite considerable length. A suitable length would appear to be between 100 and 300-ft. In order to obtain synchronous photography at these two stations separated by such distances, the two cameras must be linked together by a land line in order that their shutters may be fired synchronously (Fig. 2). No trouble has been found when using a simple solenoid for the synchronisation process.

Dependent upon the number of photographs taken, there are advantages in using either plate camera or roll film camera types. If a continuous study is to be made covering certain periods of the year or certain storm conditions, then it will obviously be advantageous to use a roll film camera, and to make the operation of the camera entirely automatic. Once again there is no difficulty in doing this, although it has not been done in the investigations which have so far been carried out. This has been due entirely to the lack of capital.

General considerations would lead one to believe that cameras having a focal plane of approximately 5-in. by 4-in., and a lens of 6-in. focal length, are quite suitable for the task (Fig. 3). Such cameras can be easily purchased, adapted and calibrated to meet the requirements of this photographic project. Photography, whenever possible, should be carried out on films giving a high resolution and having a high contrast.

The laboratory technique of measurement calls for a certain amount of experience in the use of photogrammetric plotting apparatus, and it is reasonable to assume that no operator of such apparatus could be expected to be efficient without having undertaken a period of training, lasting probably anything from six to twelve weeks. Once this training has been undertaken, however, there should be no difficulty in recording the shape and position of wave surfaces over the areas delineated as in Fig. 1. The amount of time taken to analyse each pair of photographs would of course depend upon the information required and the area covered, but in the examples which have been attempted, a pro-

* The elements of inner orientation may be considered as a knowledge of the principal distance of the lens, the position of the optical axis and the relation of the focal plane to the optical axis.

† See also example at end of text.

Wave Measurements by Stereo Photogrammetric Methods—continued

file of the waves has been produced along lines running parallel to each other and at a lateral separation of 100-ft.

Alternatively a contoured area may be obtained showing the complete pattern of the sea surface at the instant of photography. The accuracies with which this pattern is recorded are again a function of the conditions of photography and the definition within the photographs.

A further advantage of the photogrammetric method is that the surface pattern of the sea may be correlated with the amount of erosion or deposition which has been effected during a considered period of particular wave action. This can be accomplished by photography of the shore before and after a particular study of the period under investigation.

The management of the photogrammetric techniques can, of course, be reduced to a minimum by making cameras fully automatic in operation. Where selective information is required it may be necessary to have a person in control during certain periods, but under fully automatic conditions it is necessary only to release some mechanism which will enable the cameras to operate at any desired time interval. It is the latter method which is to be recommended for any considerable investigation which is to be carried out on a particular part of the shore line.

Conclusion.

The conditions under which wave measurements have to be made and the type of information required will normally determine which type of instrument is likely to prove most suitable.

The main disadvantage of the stereo photogrammetric method is the extent to which any photographic method is influenced by visibility and lighting. On the other hand the main advantages are that:

(a) the cameras, which can be shore based, are secure against damage or loss by wave action;
(b) the apparatus is free from the design problems associated with submerged instruments;
(c) maintenance and operation are facilitated;
(d) measurements are not restricted to one point or one line, but cover an area;
(e) wave height, length, shape, and direction are recorded.

The time necessary for analysis depends very largely on the care with which the cameras are calibrated, installed and operated, as well as on the amount and type of information to be abstracted.

In many cases stereo photogrammetry may prove to be the optimum method of measurement, and in some instances the only practicable solution.

Example.

An area of sea extending for 800-ft. is required for analysis.

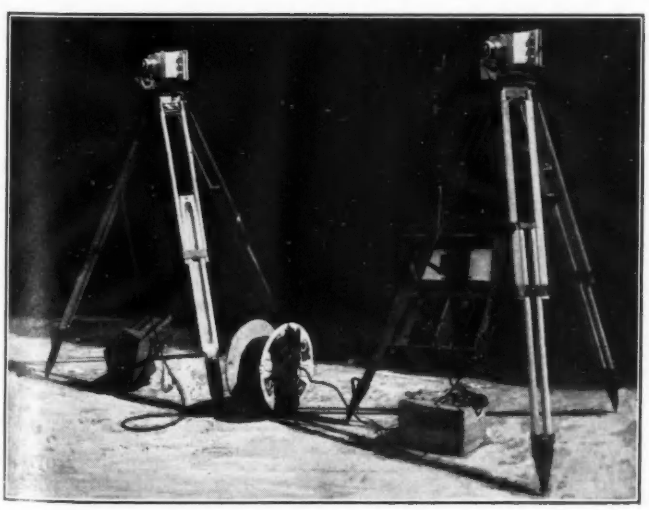

Fig. 2. Photographic equipment showing: (a) Cameras, (b) Tripods, (c) Carrying Box, (d) Land Line synchronising mechanism and (e) Plate Carrying Box.

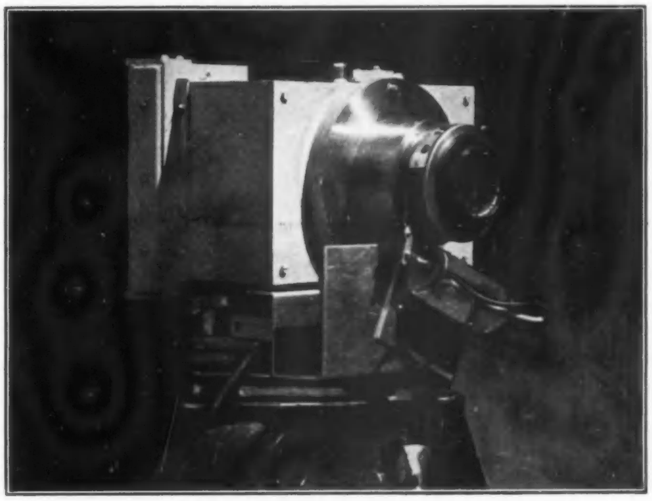

Fig. 3. 15 cm. by 10 cm. Camera, showing solenoid attachment for synchronising shutters.

Cameras available have 15 cm. x 10 cm. plates and 12.5 cm. lens. What base length would be appropriate?

For precise investigation we will restrict the distance/base ratio to maximum of 8 : 1 (i.e. k of Fig. 1=8), and, to comply with the conditions of natural binocular vision a maximum ratio of 2 : 1.

Thus longitudinal cover (i.e. in the axial direction) has to be 800-ft. $= d_{max} - d_{min}$.

$$\text{Hence } \frac{d}{b_{min}} = 2 : 1$$

$$\frac{d}{b_{max}} = 8 : 1$$

$$\therefore\ d_{max} - d_{min} = 6b = 800\text{-ft.}$$

Hence Base chosen = 133-ft.

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Barbados Deep-Water Harbour Project.

It was recently announced that tenders have been invited for the deep-water harbour project at Barbados. The closing date for tenders is February 28. It is expected that work will begin on the project early in the next financial year, which starts on April 1.

Protection Works on the Mexican Coast

The Creation of Beaches and Dunes

By MANUEL DIAZ-MARTA

(Concluded from page 309)

The Effect of Seawalls on Wind-Borne Sand.

The dykes or sea defence walls constructed in Vera Cruz have proved very effective in diminishing the drift and flight of sand by wind action. This, of course, was not the reason they were built, their purpose was to protect the city from the violence of the sea and at the same time provide added amenities in the form of a marine promenade, roadway and tram route (see Fig. 5).

In effect these seawalls protect even more effectively than artificial dunes the length of the faja in which they are constructed. When the sands tend to move and encounter a solid wall 2 or 3 metres high in their path they pile up against the wall face. The particles do not pass over because of the contained moisture and because the tide which follows the wind invades the narrow strip of beach in front of the wall, wetting it and impeding the flight of the particles. This excellent result would not have been achieved were it not for the small range of tides on this coast. The maximum oscillation is 1.2 m. On the Veracruzian coast where the seawalls are well sited, the low water does not leave a great extent of beach: 30 to 40 m. at the most, from which the wind removes little sand over the wall. It would be an error to place the seawall too far from the water edge in those areas fronting the north for the purpose of obtaining a wide beach—the desire of the general holiday public—because, in such a case, the dry sand would be blown towards the wall and, spilling over, would travel inland.

It is a proved fact that the houses of Vera Cruz situated on or near the Marine Promenade are better protected from sand invasion than those in the lee of artificial dunes. As a result, the City's authorities now allow houses and other buildings to be erected almost to the sea front, which is not possible with artificial dune areas.

These facts are easily verified. Travelling along the Mocambo Road during northerly winds, one notes the flight of sand clouds near Mocambo in the lee of a stretch of coast not yet protected with a seawall, whereas in the lee of the portion where the wall is already constructed no sand is in movement. The point where this is particularly noticeable is approximately in the direction of the wind at the end of the constructed wall.

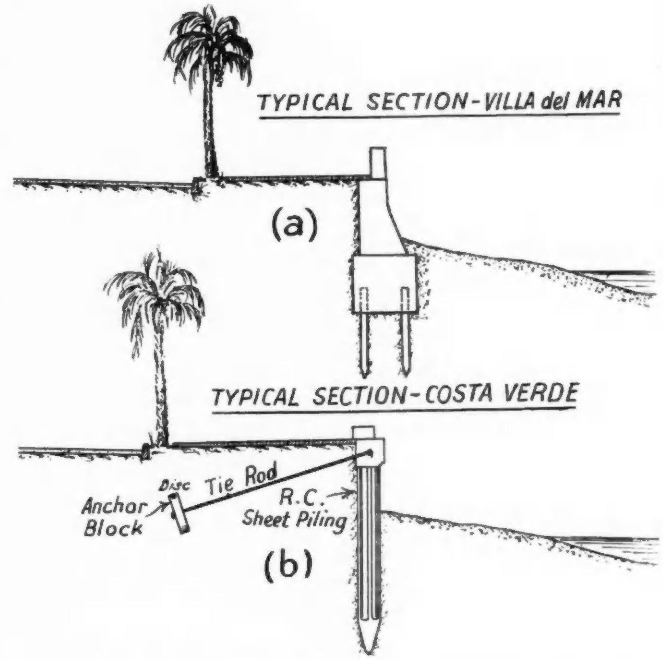


Fig. 5. Typical cross sections of seawall of marine promenades at Vera Cruz.

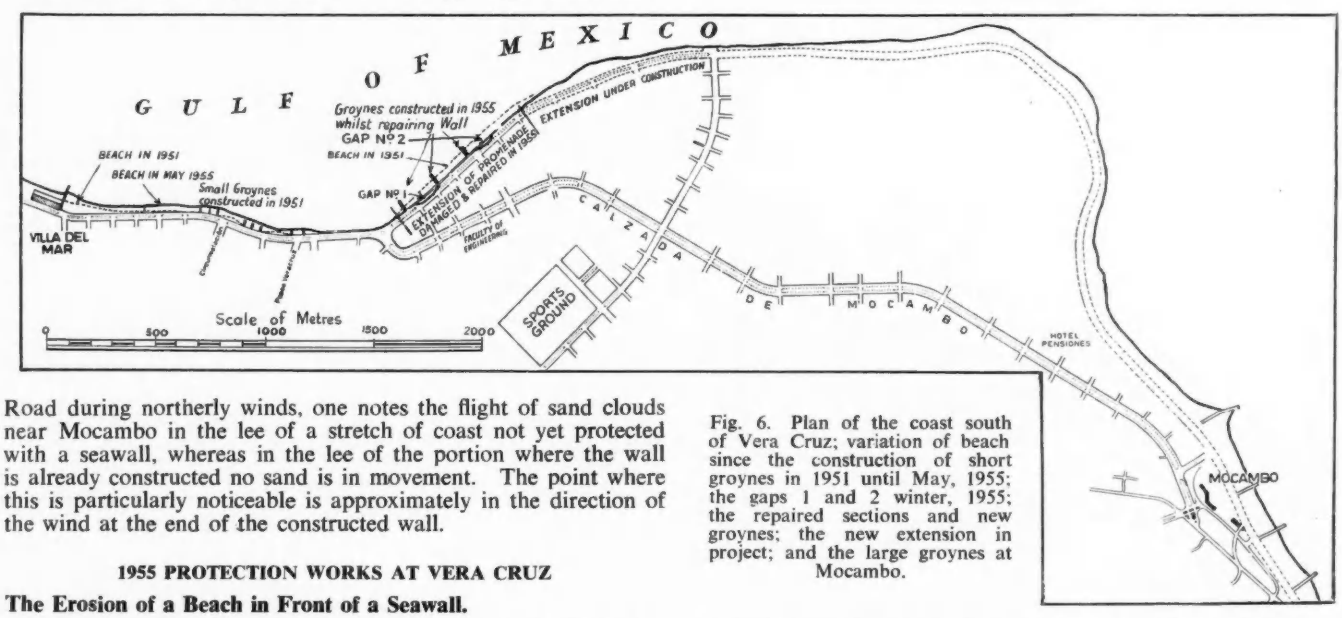


Fig. 6. Plan of the coast south of Vera Cruz; variation of beach since the construction of short groynes in 1951 until May, 1955; the gaps 1 and 2 winter, 1955; the repaired sections and new groynes; the new extension in project; and the large groynes at Mocambo.

1955 PROTECTION WORKS AT VERA CRUZ

The Erosion of a Beach in Front of a Seawall.

It is not without interest to examine the events that led to a failure of certain sections of the seawall that protects Vera Cruz on the Costa Verde front during the storm of 1955.

The wall was formed of reinforced concrete sheet piling (Fig. 5) and was constructed in 1948-49. It gave no cause for anxiety until 1951, when the construction of groynes between Costa Verde and Villa del Mar began (see Fig. 6). The object of the groynes was to protect the long stretch between these two points in which the beach had been depleted to a depth of 1.50—1.75 m. below mean sea level at the wall face. This erosion put the wall in great danger as the pile sheeting had been driven to only 2.25 m. below mean sea level.

Protection Works on the Mexican Coast—continued

The groynes were spaced at 40 m.— 50 m. apart and had lengths of 20 to 30 metres only, nevertheless they efficiently protected those parts of the wall in the greatest danger and re-established the beach in their vicinity. However, their beneficial local action proved to be prejudicial to the coast immediately to the south-east, where, in consequence the supplies to replenish the beach were considerably reduced so that the former stability was altered and the beach commenced to deplete. Once started, the disappearance accelerated by reason of the action about the vertical seawall. Before the initial depletion, the beach tempered the action of the seas (profile 1, Fig. 7a) but now, under the erosive action and the diminishing quantity of sand to absorb the wave plunge and send, the waves' break took place closer to the wall. The turbulence at the wall increased considerably and more sand was carried off sea-

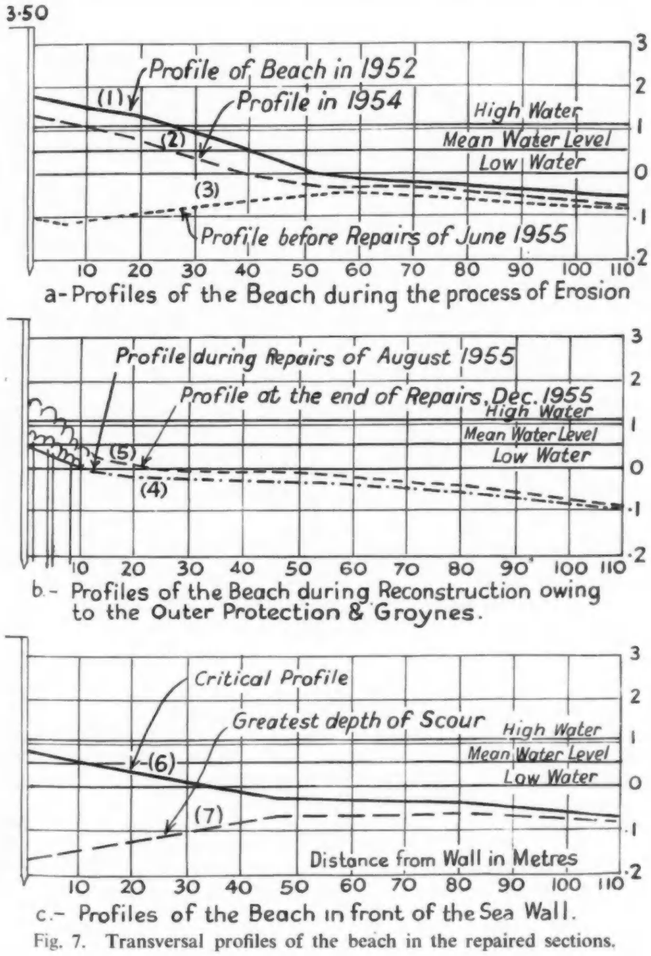


Fig. 7. Transversal profiles of the beach in the repaired sections.

ward than formerly, due chiefly to the reflection from the wall. Although after each gale the sand losses were partially made up, the beach never totally recovered (see profile 2 Fig. 7a). The erosion continued until the sand layer occupied a position that was critical (profile 6 Fig. 7c). When a fresh gale sprang up, it attacked the wall violently and reduced the bed level in front of the wall by, in some places, as much as 2.5 m. below M.S.L. In two sections water gained access into the backfill below the foundation level or toes of the piling and eventually caused the overturning of the wall. The succeeding gales until the summer widened the damage considerably. The state of the seabed in front of the wall was now as shown in Profile 3 Fig. 7a. From this, it was obvious that there could no longer be any rapid recovery by natural means and it was considered that the depletion of the bed had reached such a limit of depth that waves (in forward impact and reflection) would not deplete the beach further (see Fig. 10).

To recapitulate; should it again become necessary to construct this type of structure, or even be responsible for its maintenance, this sudden disappearance of a beach causes attention to be given to two important facts:

(1) The situation of a beach which we may call "critical" in which, when a storm occurs, the bed is eroded rapidly, passing the profile 6 Fig. 7c, with inclination always down to the sea to the profile 3 Fig. 7a, where only the submerged low tide portion slopes seaward.

(2) The situation of the bed at the foot of the wall in which the wall acting as the reflector of the waves appears to establish, at this depth, a new equilibrium. This remains constant providing there is no increase in the size of the attacking waves which orginated it (see profile 7 Fig. 7c).

In the first situation, profile 6 is the minimum level tolerable for safety of the beach. If the beach tends to reduce still further, the security must be safeguarded by groynes and the formation of an exterior protection of rubble piled against the wall face.

In the second situation, the limiting depth to which the bed may erode in front of the wall is as profile 7 (in consequence of wave

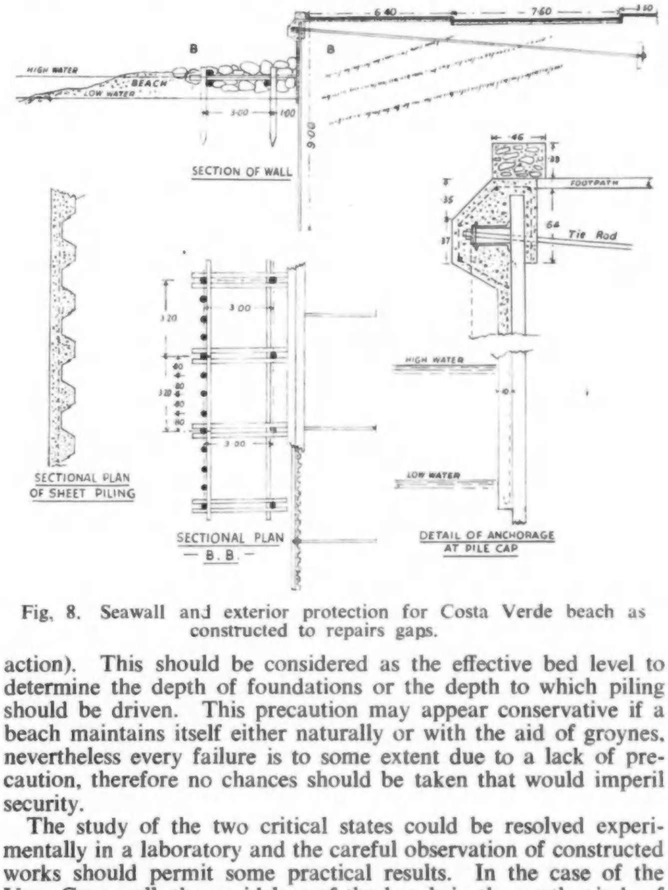


Fig. 8. Seawall and exterior protection for Costa Verde beach as constructed to repairs gaps.

action). This should be considered as the effective bed level to determine the depth of foundations or the depth to which piling should be driven. This precaution may appear conservative if a beach maintains itself either naturally or with the aid of groynes, nevertheless every failure is to some extent due to a lack of precaution, therefore no chances should be taken that would imperil security.

The study of the two critical states could be resolved experimentally in a laboratory and the careful observation of constructed works should permit some practical results. In the case of the Vera Cruz wall, the rapid loss of the beach in the north winds of winter 1955 corresponded with a seabed form as shown in profile 6 Fig. 7c. Regarding the limiting depth, the bed appeared to stabilise itself at a depth of 2.5 m. below mean sea level for wave heights that did not exceed 3.0 m.

The Effect of Repair Works upon the Recomposition of the Beach.

The two failures caused by the gales were sealed off by driving steel sheet piling 10 m. long immediately behind the fallen wall (Fig. 8). The tops of the sheeting were held by double 12-in. channels and were tied back by $1\frac{1}{2}$-in. diameter tie-bars to concrete anchorages 1.2 m. x 1 m. To avoid the corrosion of the piles they were subsequently faced with a reinforced concrete blanket and capping. The latter also envelopes the channel riband (see Figs. 8 and 11).

Protection Works on the Mexican Coast—continued

Fig. 9. Damage to coast road from Mocambo to Boca del Rio—by the cyclone "Janet."

The stretches of wall still standing were in a very precarious condition. The water depth in some places was over 2 metres, leaving only 1 to 1.5 m. embedded length for the R.C. piling of the wall.

Such a state was undoubtedly hazardous and called for prompt measures to improve stability.

When the works of repair were commenced in July, 1955, they had to be proceeded with urgently before the cyclone period (September—October) and the period of the north winds (commencing in October).

The exterior protection consisted of tipped rubble held in a timber framing of palm logs and piles. The object of this was to diminish the internal movement and to avoid dispersion of the boulders in the fine sand of the bed. The same exterior defence was laid in front of the repaired and the standing wall.

To re-establish the beach 4 rubble groynes 50 m. long from the wall were constructed at 180 m. and 190 m. spacing. During the construction observations were carefully made on the behaviour of these groynes with the aim to modify them to obtain the best results or to reinforce them with intermediate groynes if it appeared necessary.

After the works of protection had been executed, the waves, instead of beating against the wall, dissipated their energy over and through the rubble at the toe, and in front deposited the sand in such a manner that the transverse profile was considerably modified. In place of showing an inclination downwards towards the wall in the deepest points it recovered its former healthy appearance of sloping seawards. The wall so strengthened and defended, although not fully finished, was able to withstand the impacts of the strong cyclone "Janet" in the last days of September, 1955, without the slightest damage.

The section of the wall shown in Fig. 8 is that used to close the gaps and with slight modification was utilised in the finished undertaking. The experience gained permits us to recommend this type of wall for coast roads of this class in the stretches where there is a danger of rapid erosion. It is relatively economical and better than that which we have formerly proposed. The exterior protection has been simplified by the omission of the horizontal bed of logs which have been replaced by a line of driven posts 4 m. from the line of wall to act as a fence or stockade to hold the rubble close to the wall.

Fig. 10. Gap and overturned wall of R.C. sheet piling at Costa Verde after 1955 gales. Photograph taken July, 1955, at commencement of works of repair.

Erosion of a Beach in Front of Cultivated Land.

Where cultivated land comprising light soils borders on the edge of a beach it could happen that the sea will promote the accretion of a dry beach. In this case the upper borders and the most elevated part of the beach may rise to a level equal to that of the cultivated land and beyond the reach of the tides. The natural extension of the cultivated land may then take place by the spread of vegetation providing always that the winds and "rain" of sands do not impede it. In the contrary case, when the sea depletes the foreshore, the water line creeps inland and undermines the higher land platform with the consequence that falls of the banks take place. This is soon dispersed by the sea to join the littoral drift material.

Examples of this type of erosion during the works of protection of the beach between Mocambo and Boca del Rio (river Jamapa)

Fig. 11. Construction of exterior defence of seawall. The smaller boulders are shown placed by hand. The larger boulders cover these to the designed slope

first, in the stretch of the bathing station (Balneario) and, later, near the high road of Vera Cruz to Cordoba.

After the stabilisation of the Balneario beach by the construction of 4 groynes, the waves during some strong north winds attacked the banks and washed out the pavemented car park, producing a sharp declivity and causing a considerable erosion of the surrounding beach. Prompt measures were taken, and in front of the gap a rubble barrier was rapidly dumped which prevented further erosion. Eventually the barrier became embedded in the sand which had, meantime, re-accreted with remarkable rapidity and, indeed, developed into a considerable extension of beach giving ample space for bathers.

Similar occurrences at various times are recorded of the Cordoba road. Several groynes had been built but there was no longitudinal defence or any protection of the banks on which the road runs. The sea caused several washouts but no seawall was constructed. After the seasonal bad weather of 1955, for a time the beaches accreted well and there were hopes that this extended protection would suffice to defend the road. Then the cyclone "Janet" occurred when the beach had already started to deteriorate and the result is seen in the photograph (Fig. 9).

Thus once more we are driven to the conclusion that groynes do not suffice by themselves to give adequate protection against sea action and can only be efficient when incorporated with a robust seawall which must have a high factor of safety.

R. R. M.

The Choice of the Right Dredger

Factors Involved and Need for More Data*

By Dr. J. A. RINGERS, C.B.E., Hon. M. Neth. Royal Inst. of Engineers, Hon. M.I.Mech.E.

Introduction

IN 1945 Chatley[1] stated that there would be great demands for dredging after the war; first, to bring existing harbours back to pre-war standards and secondly, because improvements to meet changed shipping requirements would make a heavy call on dredging equipment.

His summary of the major developments since 1918 is so clear that it is not necessary to amend his statement; the improvement of dredging equipment is still following the lines described by him.

Development of Ocean Trade

In the 11 years since 1945 ocean trade has not only been restored, but it has steadily increased. The greater part of this development arises from the increase of water transport of crude oil and oil products. The increase in production of oilfields in overseas territories and the shipment of the increased quantities of crude oil to the refineries in Western Europe and the United States required larger vessels to lower the costs of transport. This led to deeper entrances to the loading wharfs of the oilfields and the extension of harbours.

On the other hand, a new policy to increase refinery capacity in the old countries was followed by the erection of new refineries in countries which up to then had been dependent on oil products from abroad. The refinery sites require harbours or, in existing harbours, deeper entrances. In Western Europe the refineries at Stanlow (on the Manchester Ship Canal) and at Shell Haven on the Thames, the Shell refinery at Pernis in Holland and the Shell refinery at Port de Bouc (near Marseilles) have been devloped to twice their original production or more. In the Near East the improvement of the entrance to the Shatt el-Arab is once more in the picture. New harbours are being built at Aden and Kuwait. In Australia two refineries have been completed at Perth and Geelong, and in India one has been built at Bombay. In the Far East new refineries are planned in Japan and the Philippines.

For all these oil developments a large amount of dredging is required, but the size of the Suez Canal limits the development of the dimensions of the tankers. The total tonnage passing through this canal is increasing very rapidly, mainly owing to the rise in crude oil and oil products; the number of other cargo vessels passing through is increasing only slowly, owing to the post-war political changes in the Far East.

The management of the Suez Canal decided in 1954 to execute the eighth programme of improvement to allow vessels with a draught of 36-ft. to use the canal. The increase in the number of vessels (4,533 in 1910, 6,176 in 1938, 8,686 in 1948, 11,696 in 1951, 13,215 in 1954, and 14,666 in 1955) involved the establishment of one-way traffic in 1952 after the completion of a by-pass canal near Ballah in that year.

Survey of the Development of Dredging Equipment

The first small dredgers, of the bucket type, were used in the Clyde about 1856 to improve the entrance to Glasgow's wharfs. They influenced the Dutch engineer Caland when he proceeded to open a cut through the dunes of the Hook of Holland to give Rotterdam its present direct waterway to the North Sea. Caland believed that if he only made a small pilot channel the currents of ebb and flood would scour a deep channel, with a depth of 24-ft. below M.W.L. Although the channel was formed in a few months and 7,000,000 cu. m. were washed out to sea, part of this quantity settled at the exit of the channel. The only solution was to dredge a channel through the bar and the Clyde type of dredger came into use. However, a bucket dredger, whatever its size, is very sensitive to swell. Work had to stop with the light bucket-type dredger when the swell was higher than 1-ft. The spoil of the dredgers was dropped in scows, which were towed by sea-going tugs out to sea. The work was continued about 1876 with stationary hopper suction dredgers of the type designed by the famous French engineer Bazin. These hopper suction dredgers could work in a swell of 3-ft. and thus Caland's work reached a successful conclusion in 1882.

The maintenance of the channel through the bar and the improvement of the river to the depth in the sea at the 40-ft. contour line was made possible by increasing the power of the suction dredgers and the size of the self-propelled hopper barges. Outside, in the open sea, the moored suction hopper dredgers increased in size and power, so that they could work in higher swells of shorter duration.

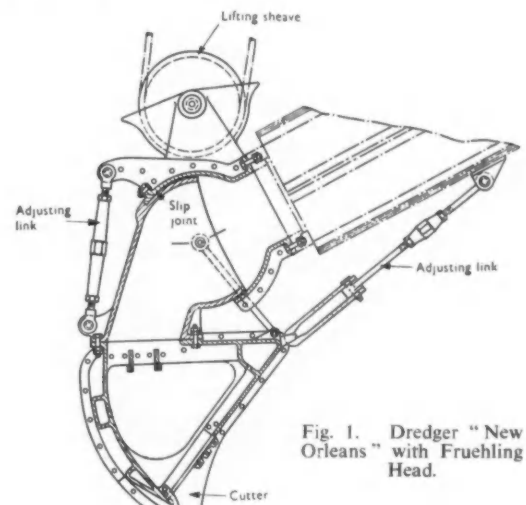


Fig. 1. Dredger "New Orleans" with Fruehling Head.

The same development can be seen in every port of Western Europe. The Germans were the first in Europe to improve the sea-going dredgers by providing the suction pipe with a Fruehling head. The original Fruehling patent of 1898 indicates the basic principle of combined scooping and suction (see Fig. 1 for an American application). The Fruehling head has been described by Chatley[2]. He concludes that the output was disappointing whenever sandy material was met with or when the mud to be excavated was very stiff. The Fruehling head was improved by the application of the Victor Guilloux principle, of twin flexible side pipes, to sea-going suction dredgers. This application was used for the first time in France on the bar of the Gironde and has been continually improved.

The latest French trailing suction hopper dredger, constructed in 1954, is the "Pierre Henry Watier" built for the French "Service des Ponts et Chaussées." It is shown in Fig. 2.

The pipeline cutter dredger cannot work in the open sea in strong cross-currents combined with a swell of more than 3-ft. The modern pipeline cutter dredgers with their installed power of 4,000 h.p. do splendid work when the location where they operate is protected by a breakwater, in completely screened harbours, and in canals. A modern pipeline dredger is shown in Fig. 3.

The grab dredgers and dipper dredges encounter the same difficulties as the moored suction dredgers where the circumstances

* Extracts from Paper presented to the Institution of Civil Engineers, October, 1956. Reproduced by kind permission.

The Choice of the Right Dredger—*continued*

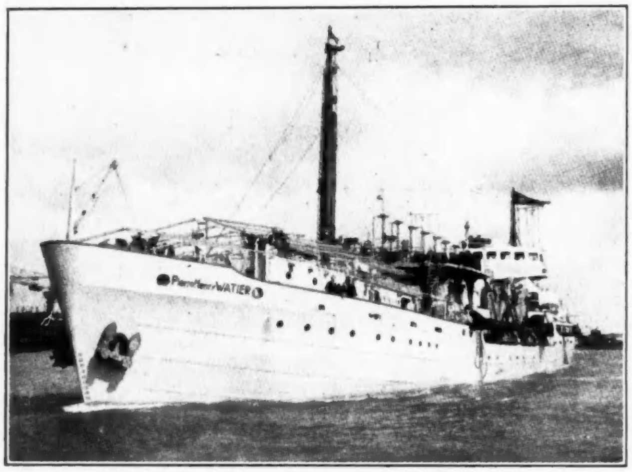


Fig. 2. Hopper Dredger "Pierre Henry Watier," built in 1954.

are the same. The grab dredger is of great value in restricted areas such as dock entrances and inside docks. The Mersey Dock and Harbour Board uses this type. Mersey No. 26, for instance, has a hopper capacity of 1,350 tons and a loading time of 135 min.

European civil engineers have developed their dredging equipment by experience and in close collaboration with the builders of their equipment. They have been assisted for many years by a large number of publications in the engineering periodicals and in the Reports and Bulletins of the Permanent International Association of Navigation Congresses, which have been published since 1885.

In the United States development followed another course. The great length of their coastlines on the Atlantic and Pacific oceans and on the Gulf of Mexico gave the Corps of Engineers of the United States Army the opportunity to develop their dredging equipment themselves. Their colleagues throughout the world have the benefit of following this development in a recent publication[3]. This publication proved that the Americans developed the first suction hopper dredger; the "General Moultrie" was commenced in 1855, whereas the first dredger of this type in Europe was developed (for the Suez Canal) in 1867. This "General Moultrie" became a casualty of the Civil War and was replaced in 1871, by the "Henry Burden," a converted sidewheeler. It worked in St. John's River and also in the harbours at Savannah (Georgia) and Charleston (South Carolina), together with the "Woodbury," a propeller-driven steamer converted in 1875 into a suction dredger, with hoppers and dredging equipment identical with those of the "Henry Burden" (the hopper capacity of the "Henry Burden" was 150 cu. yd. and that of the "Woodbury" 50 cu. yd.). The performance records of the "Henry Burden" and the "Woodbury" established with certainty that the principle of the suction hopper dredger was basically sound. It is reported that the small dredgers were "capable of working in exposed areas but much time was lost because of rough seas."

In 1902, after a contractor had failed to improve the depth of the Ambrose channel, New York Harbour, using two self-propelled hydraulic 3,000 cu. yd. hopper dredgers of the Liverpool type, the United States Government embarked on a hopper-dredger construction programme. Congress assigned in that year to the Corps of Engineers the duty of constructing and operating a number of hopper dredgers.

As in Europe, the hopper capacity and the engine power and the diameters of the suction pipes increased gradually, but a very important change may be noted in the construction of the "San Pablo" (built in 1916); instead of fixed drag-arm trunnions it had combined elbow ball-joints, mounted in slide plates, which moved vertically in guides on the ship's sides. This slide arrangement made it possible to raise the entire drag arm from the operating position to main deck level when travelling to and from the dumping grounds or when berthing the dredger. This new construction made work possible in rougher seas than any of the older dredgers had allowed.

However, still more improvements were needed. Up to 1920 the hopper doors had been of the square or rectangular hinged type. When opened they hung partly under the ship's bottom and caused difficulties when the dredger was listing heavily. Gradually the American engineers overcame this difficulty with the conical and cylindrical dump valves.

There is a definite difference in the cross-sections of the hoppers as built in the United States and in Europe. The hoppers of the most recent United States hopper dredger, the "Essayons" (built in 1949) have vertical walls for 60 per cent. and a slope to the hopper door of 60° for 40 per cent. of the distance from overflow level to valve. In French-and Dutch-built hopper dredgers the walls are not vertical, but have an inclination of 52°—70° throughout their whole height. Examples are the "Paul Solente," a French-built hopper dredger constructed in 1947 and in use by the Suez Canal Company, and the Dutch dredger "Geopotes II," built in 1912.

Experience in Europe showed that with very compacted material, such as quicksand or mixtures of fine sand with silt, a bridge is formed over the opened hopper doors between vertical walls which necessitates jetting with water at high pressure to break these bridges. These water jets also serve to wash out the hoppers thoroughly. A further improvement is to fit the ends of the wash-out pipes with swivel heads, so that the wash-out streams can be directed to any section of the hoppers.

Drag heads have also been improved to meet the different types of soil to be removed. Chatley gave some interesting information and illustrations in his Papers. Since then the U.S. engineers have continued to perfect the drag heads, as shown in Figs. 4 and 5.

The capacity of the hoppers of hopper dredgers is influenced by the distance from dredging location to dumping ground as shown in Table 1.

The Corps of Engineers of the U.S. Army, by the continuous improvement of its dredging equipment, has set the builders of new harbours in other parts of the world a good example. They are aware that the trailing suction hopper dredger is the best dredger in rough seas. For improvement of harbour channels and inter-ocean canals, it has moreover the advantage over the moored bucket and suction dredgers, and over the pipeline cutter dredgers, of being able to move out of the way of passing ocean vessels.

In Europe the development of hopper dredgers followed its own line.

In the rough seas on the outer bar of the Gironde, in France, where the depth only varied between 20 and 23-ft. below zero of the marine maps, an important channel, approximately 5 miles

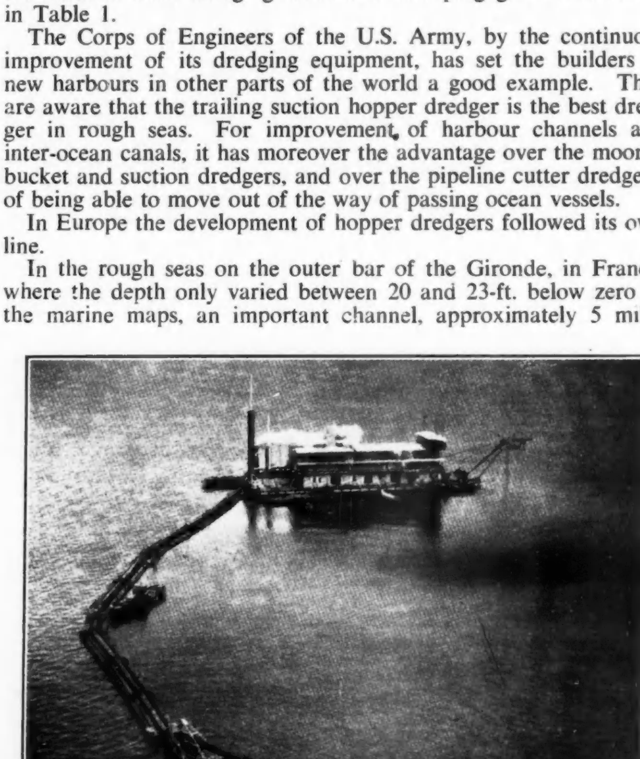


Fig. 3. Pipeline Cutter Dredger "Louis Perrier," built in 1956 for Suez Canal Company.

The Choice of the Right Dredger—continued

TABLE 1. Influence of Distance to Dump (one way).

District	Year of observation	Name of dredger	Volume of hopper: cu. yd	Distance to dump: miles	Time of loading: hr. min	Time from cut to dump: hr. min	Dumping time: hr. min	Average loads: cu. yd	Character of soil
New York . .	1949	*Goethals*	5,000	13·40	3 31	2 35	0 12	4,140	64% clay-silt; 36% sandy
Jacksonville .	1949	*Lyman*	700	2·08	0 43	0 26	0 08	633	49% clay-silt; 51% sandy
Maracaibo . .	1950	*Sandpiper*	1,050	2·40	1 41	0 40	0 11	1,005	Fine sand with approx. 5% silt
Liverpool . .	1955	*Leviathan*	6,600	20	2 0	2 35	0 20 to 0 30	6,600	Sand of 111·9 to 124·3 lb/cu. ft
		Flood loads		5 to 10	2 0	0 85			
		Ebb loads			2 0	1 20			

long, winding through the bar, gave a connection with Bordeaux for ships of 28-ft. draught. However, this pass was not permanent and the French engineers were challenged to find a way to dredge and maintain a better approach to the Gironde. The Chief Engineer of the French Navy, Victor Guilloux, presented about 1927 a plan for a semi-flexible suction pipe (drag) directed to the stern (like the United States hopper dredger "New Orleans," built in 1912). This drag has three movable parts; a ball-and-socket joint R, which allows a vertical movement of the drag head independent of the drag pipe, and between this ball-and-socket joint and the turning joint on the top of the suction pipe are two swivel joints J, which give complete mobility in rough seas.

After many tests a new hopper dredger[4], the "Pierre Lefort" (Fig. 6) was built which can move freely in a rough seas with waves of from 12-ft. to 13-ft. 6-in. It has two side drags in the direction of the stern. Each drag (Fig. 7) has two parts, joined by a ball-and-socket joint (R), which gives the drag head a degree of freedom by allowing it to turn on a horizontal shaft. The upper element is connected to the hull by a universal joint and has two Guilloux swivel joints (J); these joints can be moved in all directions. They hang during dredging. The drag head does not hang, but with these devices can follow the changes on the bar surface and is independent of the rough seas. Fig 8 shows the modern swivel joints J.

The Future Depths to be Created in Seaports and Their Entrances.

The P.I.A.N.C. decided at the meeting in Brussels on June 5, 1951, to set up an International Committee for the study of depths to be created in seaports and their entrances, as well as at their berths. Before appointing members of this committee, it was decided to have a National Committee in each of the maritime countries to make a preliminary study and submit a report with concrete conclusions to be used as the basis for all further studies and deliberations of the International Committee. The last of these national reports[5] was published in 1955.

The conclusion is that, for the time being, the draught of ocean tankers will be limited to 40-ft. Depending on swell and on the

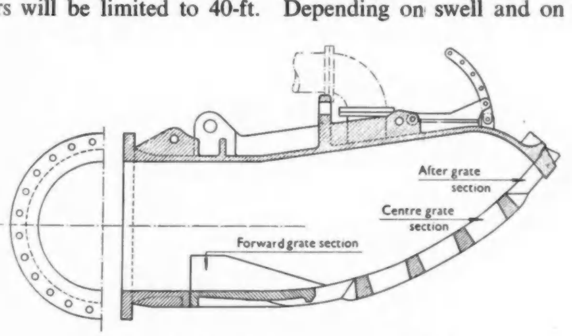


Fig. 4. Modern "Ambrose" type drag.

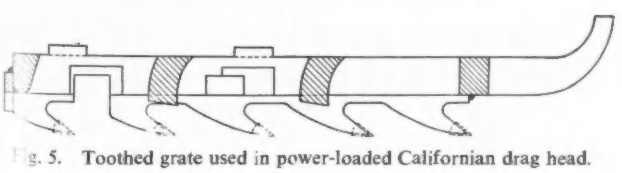
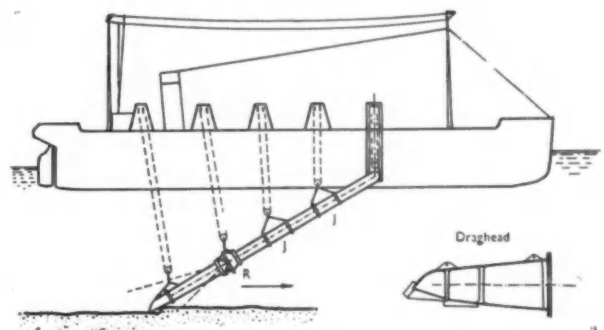
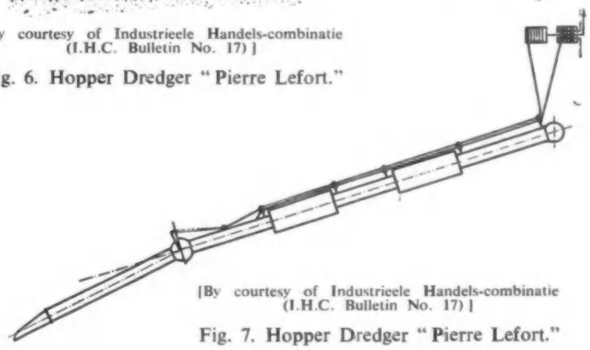


Fig. 5. Toothed grate used in power-loaded Californian drag head.



[By courtesy of Industrieele Handels-combinatie (I.H.C. Bulletin No. 17)]

Fig. 6. Hopper Dredger "Pierre Lefort."



[By courtesy of Industrieele Handels-combinatie (I.H.C. Bulletin No. 17)]

Fig. 7. Hopper Dredger "Pierre Lefort."

importance of the harbour (which will decide whether vessels can enter over the whole tide or only at H.W.) dredging will be necessary to a level of 50-ft. below L.W. On p. 13 of reference 3 there is a statement that the Ambrose channel of New York Harbour is to be dredged to 45-ft. and the main ship channel to San Francisco to 50-ft.

The links between the Atlantic and the Pacific Oceans, in Panama and in Egypt, are also in the limelight. Many years ago extensive studies were made concerning the Panama Canal. The latest Report of 1946: "A sea level canal in Panama of larger dimensions" (a canal which will make possible two-way traffic over the whole length) came to the following conclusion: in a lock canal the speed of a ship would be 8 knots and in a sea-level canal 10 knots. The depth of a sea-level canal will be 60-ft., and the width at a depth of 40-ft. will be 500-ft. In another project the bottom width is 600-ft.

The Suez Canal Company does not only write reports; programmes of improvement follow each other very quickly (7th programme in 1949, 8th programme in 1954). In this canal the traffic is so overcrowded that in order to prevent collisions convoys with one-way traffic go up and down and all vessels have their speed limited to approximately 7 knots. The present maximum draught of oil tankers in the United Kingdom is 35-ft. and no change is likely until the Suez Canal is deepened.

Factors Influencing the Choice of the Right Dredger

In North America and Western Europe it it not difficult to choose the right dredger, since all types and sizes are available and transfer of a dredger is not very costly. Beyond Suez and south of the equator, however, the replace of the wrong dredger by the right

The Choice of the Right Dredger—continued

one costs a lot of time and money. Except for a large part of South America, where dredging is already developed, many less privileged countries will not be able to develop their own dredging equipment for many years to come. During that interval they will still require assistance.

To engineers who have worked on these overseas countries it is well known that, in general, records on wind, meteorology, and waves do not go back very far. A remarkable point is that for the heaviest storms, the typhoons and the tropical storms, records are relatively old and reliable. Data on the typhoons in the China Sea have been kept in the Central Observatory at Manila for the period 1902-1934, and on tropical cyclones for 1949 and 1950; the Royal Observatory of Hongkong gives a statistical survey of typhoons from 1884 to 1949 and of typhoon tracks in 1946 and 1948.

With this information it is possible to calculate the height of the swell, but on this swell local storms produce waves about which no information is available and which, superimposed on the swell, can have disagreeable reactions on dredgers, structures, etc., in the sea.

It is the author's experience that in general the following factors must be known:—

(a) The depth of the sea bottom where a harbour basin and an approach channel are projected.

(b) The changes of the sea bottom caused by the changes of the monsoons and possibly by the influence, over a long period, of coastal sand currents.

(c) The tides, rhythms and ranges.

(d) The height, length and periods of waves and swell.

(e) The wind; land and sea breeze, prevailing winds, details of direction and force.

(f) The typhoons, cyclones and hurricanes and their influence on the swell and on the location where harbour and approach channel are projected.

(g) The strength and direction of coastal currents and coastal sand transport.

(h) The composition of the submarine soil.

(i) The area acceptable for dumps of the spoil of the dredgers.

(j) The location of existing workshops, dock facilities, water supply, medical aid, hospitals and possibly of recreation.

(a) **The Depth of the Sea Bottom.** The best locations for the dumping of spoil can be found from the excellent charts of the British and other admiralties, from which the depth of the sea in the vicinity of the works to be constructed can be ascertained. These charts also give basic figures for the top soil of the bottom. However, it must be borne in mind that these maps are made for navigation; they give the highest points of a section; in between there may be lower parts. Furthermore, velocities and directions of currents are stated.

" Pilot " books published by the Hydrographic Department of the Admiralty, London, and normally the specifications for the tender will provide further information. This provides an opportunity of finding out where dry docks or ships are available, and the distances thereof from the site. This knowledge is required for large-scale repairs. If the distance is relatively small the dredger does not need many facilities aboard, but in all overseas territories it will be wise to have either a floating workshop available or at least a workshop on the dredger with welding equipment and a store of numerous spare parts.

(b) **The Changes of the Sea Bottom.** In countries where the monsoon change the direction of currents and winds the " Pilot " gives elaborate information. The " Pilot " gives further ample information on population, meteorology, currents, fuelling stations, etc.

(c) **The Tides, Rhythms and Ranges.** The tides are of great importance in dredging when starting the initial cut, especially in jobs where a channel is to be formed through a bar which closes off a river-mouth or a bay. If there is current over the bar, agitation is of great assistance in the first stage of the forming of a pilot channel. The hopper dredger is the right dredger, but if possible a small type with a shallow draught should start the job at high water, pumping the dredged spoil overboard until a pilot channel is formed; gradually the pilot channel becomes so deep that even at low water the large fully loaded dredger can pass dredging over the bar and dump on the agreed dump site.

If there is no tidal current, bars can be removed, except in times of rough seas, by other types of dredger, such as the moored suction dredger or bucket dredger, both loading into hopper barges or dump barges in tow, etc. A pipeline dredger can also be chosen if the dump is not too far away.

(d) (e) **Wind and Waves.** Information on wind is of the greatest importance. The wind originates waves and the waves—possibly combined with currents—make dredging impossible for hours, days or weeks.

The " Pilot " books give only brief information for each port of the world on the prevailing wind. For dredging this information is insufficient. Wind rarely blows in the same direction. The prevailing wind is the wind of the highest frequency and force. A study carried out for 6 years on a job in the Western Hemisphere has compared the wind frequency and the maximum force in miles per hour during the month from the various directions and for various years. It is interesting to compare these variations with the total hours of effective working time, the cubic yards dredged on the outer bar (no protection) and on the inner bar (protected against swell and waves in the sea). An example gives the dredging analyses for the year 1954 (see Table 2).

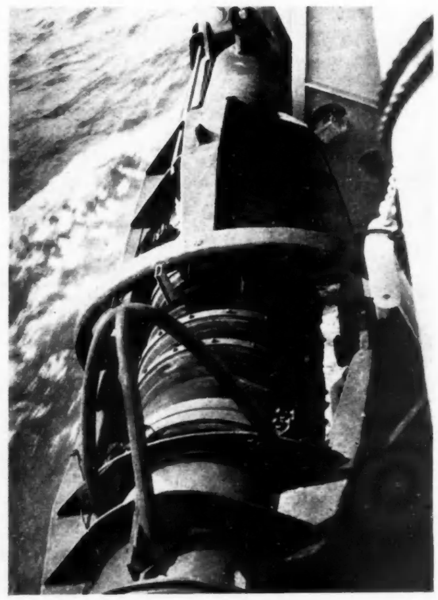


Fig. 8. A modern swivel joint in the suction pipe of " Pierre Henry Watier."

If for any work a survey of this type were available for works in any part of the world a good estimate would be possible of the effective working hours, which is a main point in the choice of the right dredger, not only with regard to the possibility of having maximum output, but also for the size and the number of dredgers.

In the same area where the analyses have been prepared trials were made to build up wave statistics. This was done by evaluating height and periods of waves from the dredgers. These observations can now be automatically recorded by new instruments, some of these give graphs excluding the tidal movement, others give wave heights and periods on the tidal curve.

(f) **Typhoons, Cyclones and Hurricanes.** Nowadays warnings are given of the possible arrival of typhoons, hurricanes and the like. A dredger is provided with radio and can normally run for shelter in time.

After the hurricane has passed, the swell originated by the heavy impact on the surface of the oceans and inner seas is felt over great distances. The periods and length of the swell are normally long, namely, periods of 16 sec., with a wave length of 1,000-ft. and a wave height of 8-ft. This slow motion does not hinder a hopper dredger, but it does when the breakers develop to higher and shorter waves. It depends on the submarine slope, if, where, and how long dredging with a hopper dredger is interrupted.

(g) **Coastal Currents.** Coastal currents exist in all seas under the influence of tidal movement. Their velocity is inscribed on the Admiralty charts, and is never the same for the whole day. Their

The Choice of the Right Dredger—continued

TABLE 2. Dredging Analyses of M.V. Sandpiper for the Year 1954.

Month	Outer bar					Inner bar				
	Dredging: hr. min	Dumping: hr. min	Total: hr. min	Dredged: cu. yd	Rate of dredging: cu. yd/min	Dredging: hr. min	Dumping: hr. min	Total: hr. min	Dredged: cu. yd	Rate of dredging: cu. yd/min
Jan.	38 40	35 55	74 35	22,650	9·76	191 20	255 50	447 10	176,960	15·41
Feb.	107 05	98 05	205 20	60,150	9·36	146 45	253 10	399 55	121,975	13·85
Mar.	65 05	64 30	129 35	35,225	9·02	188 55	346 40	535 35	153,025	13·50
Apr.	56 05	54 40	110 45	30,625	9·10	107 35	254 30	362 05	138,525	21·46
May	224 05	189 35	413 40	124,350	9·25	63 00	128 05	191 05	62,125	16·44
June	82 20	78 35	160 55	44,325	8·97	157 40	346 15	503 55	127,575	13·49
July	6 00	6 50	12 50	3,050	8·47	70 45	165 20	236 05	49,150	11·58
Aug.	139 55	141 25	281 20	67,725	8·07	127 45	257 40	385 25	89,750	11·71
Sept.	178 45	175 00	353 45	96,240	8·97	49 55	98 45	148 40	35,700	11·92
Oct.	310 45	278 55	589 40	198,180	10·63	24 20	35 15	59 35	15,850	10·86
Nov.	166 30	135 40	302 10	103,500	10·36	45 35	74 10	119 45	27,370	10·01
Dec.	170 25	146 40	317 05	132,750	12·98	52 50	84 40	137 30	27,925	8·81
Total	1,545 40	1,406 00	2,951 40	918,770	9·91 (av.)	1,226 25	2,300 20	3,526 45	1,025,920	13·94 (av.)

Effective working time (days): 270 (123 outer bar; 147 inner bar).
Non-effective working time (days): 95 (dry-docking 64; repairs in area 18; bar to bar, stores, etc., 13).
Total amount dredged (cu. yd): 1,944,690 (918,770 outer bar; 1,025,920 inner bar).
Average dredged per minute (cu. yd): 11·7 (9·91 outer bar; 13·94 inner bar).

velocity is normally not high enough to erode a sandy coast. However, when the wind blows on the coast it depends on the angle which the direction of the wind makes with the coast whether sand will be eroded and dragged away with the coastal current. Most sand is lost on the waterline where a strong wind erodes the wet beach and if the component of the wind force in the direction of the coast is strong enough, the wind brings the eroded sand into the coastal current. This does not mean that this sand is transported with the velocity of the wind. Very often the erosion of one point is partly refilled with material eroded some distance back along the coast.

Nevertheless the author came to the conclusion that annual sand transport in many countries may be estimated at 500,000—1,000,000 cu. yd. This rate depends on the configuration of the coast in relation to the changing direction of the wind and the nature of the coast (sand, rock, clay, or silt layers between, etc.).

If a channel is opened through a bar, the sand current, the original builder of the bar, will not pass across the channel but will leave a large portion of its sand in the new channel. This sand must be added to the amount of the mathematical content of the new channel.

(h) **Submarine Soil.** It is well known that a suction hopper dredger cannot remove stiff clay, boulder clay, chalk and rock; furthermore, with coarser sand the hoppers are more quickly filled and dumped than with such materials as fine sand, soft clay and mud, which are likely to give a high content of overflow, and the hoppers, which easily discharge coarse sand, etc., are difficult to discharge without the assistance of water jets.

To choose the right dredger it is essential to make a complete survey of the soil to be removed and also below that level, because a project is not complete without an investigation for a future extension.

The results of borings are essential for the choice of the right dredger, but since borings take a considerable time at sea, which is nearly always in motion, the number of borings is normally limited and does not give a complete survey. Many specifications for tenders try to shift the responsibility for these borings on to the contractor by stating that the contractor must carry out extra borings if he doubts that the information given is complete. However, the time is normally too short to double the number of borings and he starts the work with the danger that he will meet layers of hard material between the given borings. In that case he must order from home another type of dredger able to complete the work, with a consequent loss of time and profit.

The author knows of a case in which a geological survey had shown that a layer of rock might be encountered; the Principal had inserted the following very reasonable clause:—

Clause 16. Definition of rock: By rock is understood under the terms of the present Contract any material that cannot be dug out by a hydraulic suction dredger with a discharge tube of a diameter not less than 68.6 cm. (27-in.) with a minimum motor capacity of 3,500 h.p. and 500 h.p. of the main pump and of the cutter head respectively, using a cutter head with knives or teeth without the rate of production decreasing under 750 cu. m. of material per effective working hour. With respect to hopper dredgers, by rock shall be understood, under the terms of the present Contract, any material that, on account of its quality, reduces by 50 per cent. the normal efficiency of dredgers of this type.

The Soil Mechanics Laboratory in Delft (Holland) developed many years ago the Dutch penetrometer. A steel cone is pressed in the soil, the pressure is recorded and converted into kg./cm.^{2} This process gives a quick survey of the nature of successive layers. The instrument is not strong enough to penetrate and pass through layers of a resistance higher than 50 kg./cm.^{2} This type of investigation is six to ten times quicker than boring, and thus makes it possible to have a more complete knowledge of the material to be removed by dredging.

After the completion of intensive soundings, borings are made at interesting locations indicated by the penetrometer soundings. These borings must yield undisturbed samples. This is easy for all cohesive matter, but not for sand unless it is cemented by silt or mud. The Delft Soil Mechanics Laboratory is now developing a new type of sampler for sampling loose sand and mud. Where sampling of undisturbed loose material is possible the volume of material in situ can be compared with the volume of material in the hopper, which is more loosely packed.

(i) **Dumping of Spoil.** The specifications must not leave any uncertainty and must prescribe strict supervision by day and night. One of the methods of supervision is to sound the depth over the dump, using vertical settling poles to determine how much the original sea bottom has sunk.

(j) **Workshops, Dock Facilities, etc.** The size of the dredger is also defined by the volume taken up by the facilities which must be available on board. In the more developed countries the distance is short to docks and slipways, to well-equipped workshops, and to the factories where spare parts are in store, so that repairs can be quickly effected. Hospitals, water supplies and medical aid, etc., are also near at hand. In areas where this is not the case, especially in tropical countries, the space required in addition to that for hoppers, engine rooms, cabins, etc., must be very large. It has, moreover, been proved that in humid tropical areas (especially near the sea, where tropical vegetation is abundant) air conditioning of all living and working spaces is necessary, even for the engine room. In such countries, far from the home port of a modern dredger, continual work by day and night is necessary

The Choice of the Right Dredger—continued

and accepted in order to complete the job as quickly as possible and at the lowest price. A repair shop and large store rooms must be available on board ship, as well as roomy galleys and messrooms, and all modern sanitary equipment. In this way the relation of hopper capacity to the size of the vessel is continually increasing.

From the above-mentioned factors it will be apparent that information on tides, waves, wind, typhoons and currents (c), (d), (e), (f) and (g) cannot be produced in the short time available between the decision to open or improve approaches to harbours and rivers and the planning of these works. At least one year's records are necessary to provide engineers with a reliable tidal forecast. On the other hand information on force and frequency of wind over a period of 3 years might not be sufficient, and at least 6 years' investigation is better for the planning of new harbours around the Indian Ocean, the western Pacific, the eastern Atlantic Ocean, and in the Persian Gulf.

Conclusions

1. Without complete information, as summarised above, it is not possible to choose the right dredger.

2. In order to be able to plan future dredging works, particularly in undeveloped countries, it is necessary to start as early as possible to assemble records on tides, wind, typhoons and coastal current. It is suggested that prior records should be built up by an International Body of experts on a world-wide basis. The Technical Assistance Committee of the United Nations may be the best sponsors for such a body.

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1 Herbert Chatley, "Dredging machinery." J. Instn. Civ. Engrs., vol. 24, p. 72 (Apr. 1945). See Introduction.

2 Herbert Chatley, "The principles of drag-suction dredging." J. Instn. Civ. Engrs., vol. 12, p. 185 (June, 1939).

3 "The The hopper dredger; its history, development and operation." U.S. Army, 1954.
A complete survey of this book was given in "Dock and Harbour Authority" during 1955 and 1956.

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5 Perm. Int. Assocn. Nav. Congresses, 1955, Bulletin No. 42.

Book Reviews

Kempes Engineers' Year Book (Two volumes in case). Published by Morgan Bros. (Publishers) Ltd., 28, Essex Street, London, W.C.2. Price 82s. 6d., postage 2s. 6d. extra.

The 1957 (62nd) Edition of this famous year book, which has been edited under the direction of the Editor of "The Engineer," is now available. To the older members of the engineering professions, "Kempes" is a familiar friend needing no introduction, but for the benefit of students and others new to engineering, it should be said that it is a reference book in which practically every branch of the engineering sciences is covered in an authoritative and up-to-date manner.

There are 79 chapters in the two volumes, containing the answers to enumerable queries, to assist in finding which, the Index contains 17,000 references. A feature of considerable value, which will commend itself to many readers, is the short bibliography at the end of most of the chapters, detailing the standard works on the various subjects therein dealt with. Thus what "Kempe" says on any subject can be readily augmented, if desired, by further study of the best of the relevant text-books.

In accordance with the editorial policy of keeping the contents up-to-date, every chapter is revised each year by eminent authorities. In a reference work of this nature, this is an important consideration in view of the rapid developments taking place in many fields of engineering to-day.

Major changes in the 1957 edition include a new section on "Diesel Locomotives," added to "Railway Engineering" which, in addition, has new matter on "Electric Traction" and "Brakes"; together with an entirely rewritten chapter on "Gearing." Useful additions have been also made to several other chapters.

One of the best works of its kind, "Kempes" may confidently be considered to be an indispensable book of reference on every engineer's book shelf, whatever the special branch in which he is engaged.

H. F. C.

"Disease Control and International Travel"—A review of the International Sanitary Regulations, by H. S. Gear and Z. Deutschman. Published by the World Health Organisation and obtainable from H.M. Stationery Office, London, S.E.1. Price 3s. 6d.

This publication reviews the International Sanitary Regulations which have governed world-wide trade and traffic since their implementation in October, 1952, and estimates their success. The recent history of each of the quarantinable diseases is given, together with brief statistics of their decline. It is pointed out that in the last four years not a single epidemic has occurred as a result of international travel. Only 45 ships and one aircraft have been reported as infected. It is emphasised that general world sanitary improvement, together with the wider use of the new insecticides and rodenticides, which have helped to reduce the threat of infection, have contributed to the decline in the incidence of cholera and the plague. Yellow fever is now the most serious problem in international quarantine, but mosquito eradication campaigns and widespread vaccination have done much to improve the situation.

Summing up, the authors point out that in view of the irresistible size and significance of rapidly growing world transport, the application of the old-fashioned quarantine techniques will be of little avail, and will grow largely redundant with the improvement of international sanitary conditions.

"The Law on the Pollution of Waters." By A. S. Wisdom, L.A.M.T.P.I. pp. 296. Published by Shaw & Sons Ltd., Fetter Lane, London, E.C.4. Price 37s. 6d.

The Law dealing with Water Pollution is extremely obscure and complex, being contained in some hundred different Statutes, and this original work for the first time co-ordinates this vast and interesting field of law ranging from atomic waste to waterworks.

The material is presented in a logical and common-sense manner interspersed with practical notes and quoting nearly three hundred cases. The Author has considerable practical experience with one of the country's foremost and oldest river pollution authorities and the wealth of information produced by this extensive research will prove invaluable to both technical officers and legal advisers.

"Free Ports and Foreign-Trade Zones. By Dr. Richard S. Thoman. Fully illustrated with 54 photographs and drawings, 35 sets of tables and an Index. Published by the Cornell Maritime Press, Cambridge, Maryland, U.S.A., $7.00, and in the United Kingdom by Putnam & Co. Ltd., 42, Gt. Russell Street, London, W.C.1. Price 52s. 6d.

This volume gives a summary review of the free port movement from its beginnings to the present day, with emphasis on specific examples drawn from northern Europe. The lack of a definite trend towards success or failure of the U.S. Foreign Trade Zones has prompted a series of questions in the author's mind, which has resulted in this study of the free port as an effective device in present-day world commerce.

The author, who is an Associate Professor of Geography at the University of Omaha, has made a careful study of all the free ports of Germany, Denmark, Sweden and Holland and of the foreign trade zones in the United States and in this compendium attempts to deal with three main points. Firstly, the trends of functional significance of the free port as part of its associated total port and of its host country; secondly, the applicability of these trends to the foreign trade zone system of the U.S.A.; and lastly, the study of alternatives that have been developed as substitutes for a free port.

The book spans rather than fills the gap of literature dealing with free ports and so is likely to be a useful addition to any maritime bookshelf.

Electrical Distribution as applied to Docks

Section III.—The Cable System, H.V. and L.V.

By C. H. NICHOLSON, M.I.E.E., M.I.Mech.E., F.R.S.A.

(Continued from page 313)

The question of the voltage of supply may be broadly governed by the size of the dock system and the consequent demand and in general a demand of 500 K.W. or under may be supplied at low voltage but this again depends upon the capabilities of the L.V. network of the Electricity Supply Authority.

The preferred standard 3 phase A.C. low voltages are:

Between Line and neutral	240 volts
Between Lines	415 volts

and the preferred standard 3 phase A.C. high voltages are:

Between Lines	11 K.V.
	33 K.V.
	66 K.V.
	312 K.V.
	264 K.V.

3.3 K.V., 6.6 K.V., 22 K.V. are other standard voltages in use by Authorised Undertakings. (Extract from BS 77 1947.)

Usually the electricity supply given to dock areas is either 6.6 K.V. or 11 K.V. and sometimes 22 K.V. depending upon locality. In all examples taken for illustration purposes the supply is assumed to be given at 11 K.V.

Current Carrying Capacity

The current carrying capacity of the various cables comprising the distribution system should be considered under the following headings:

(1) The normal maximum continuous rating.
(2) The overload capacity.
(3) The short circuit capacity.
(4) The current carrying capacity as defined by the permissible voltage drop.

Item No. (4) does not require consideration for the H.V. system as on dock areas, relatively small distances are involved but it does require consideration as far as the L.V. distribution is concerned.

Under (1) the current carrying capacity is limited by the temperature rise of the dielectric particularly that nearest the conductor. The sources of heat being the I^2r losses in the conductor itself and which rise as the square of the current, the losses in the dielectric itself, and the sheath loss. Dielectric loss is almost negligible under voltages of 33 K.V. and at temperatures below 70°C. Sheath losses are greatly increased by the use of single core sheathed cables although these can be reduced by suitable spacing and bonding but unless absolutely unavoidable single core cables should not be used on dock installations served with alternating current and the use of steel armouring under such conditions is not recommended on account of the large sheath losses involved.

The fundamental law upon which the calculation of current carrying capacity of a cable as defined by the temperature rise, is based upon the fact that when the cable has attained a steady temperature the amount of heat generated is equal to the amount of heat lost. The dissipated heat is taken up by the ground where cables are buried, and by the air when suspended from supports. It is clear, therefore, that the lower the temperature of the ground or air the lower will be the temperature of the cable, also with respect to the ground, the greater the heat conduction, the lower will be the temperature of the cable. Where cables are grouped, therefore, the greater the distance between the centres of the cables the lower will be the cable temperature. The tables given below are for 3 core L.V. H.V. paper insulated lead sheathed and single wire armoured cables laid direct in the ground for use on systems having an earthed neutral.

Table 3.1

Current Carrying Capacity of Paper Insulated Cables

Area of Conductor sq. ins.	LAID DIRECT IN GROUND — A.C. Armoured 3 and 4 core shaped L.V.	3 core shaped 6.6 K.V.	3 core shaped 11 K.V.	SUSPENDED IN AIR — A.C. Armoured 3 and 4 core shaped L.V	3 core shaped 6.6 K.V.	3 core shaped 11 K.V.
	Ambient Temp. = 59°F soil temperature			Ambient Temp. = 77°F.		
	Amps	Amps	Amps	Amps	Amps	Amps
.0225	93	88	85	78	81	78
.04	128	123	119	110	115	112
.06	162	156	150	143	149	143
.10	216	208	200	196	205	196
.15	271	261	250	252	262	252
.20	320	307	291	302	312	300
.25	358	348	331	344	360	346
.30	400	386	369	385	404	384
.40	465	446	427	469	486	464
.50	517	491	471	537	552	524
.60	568			585		

It should be noted that no account is taken of voltage drop in the compilation of the above current carrying capacities.

As previously indicated the manner of laying cables has bearing upon the temperature rise and the consequent current carrying capacity, Table 3.2 therefore, is given indicating the rating factor for various spacings.

Plain lead sheath deduct 2% } up to and including .3 sq. inch
Armoured and served add 2% } cable.

Final Cable temperature
158°F. up to and including 6.6 K.V. } 3 core cables
149°F. for 11 K.V. }

Temperature Rise: 81°F. for L.V. and 6.6 K.V. 72°F. for 11 K.V. in air

Temperature Rise: 99°F. for L.V. and 6.6 K.V. 90°F. for 11 K.V. laid direct in the ground.

Table 3.1 (contd.)

Current Carrying Capacity of Cables

A.C. Armoured Paper Insulated Cables in Ducts based on E.R.A. Report F/T.128.

Area of Conductor	L.V. 3 and 4 core	6.6 K.V. 3 core belted	11 K.V. 3 and 4 core belted
	Amps.	Amps.	Amps.
.0225 sq. in.	75	76	73
.04	101	104	100
.06	130	132	127
.1	172	173	167
.15	211	217	209
.2	246	254	244
.25	277	288	276
.3	307	313	301
.4	357	361	349
.5	400	406	392

Grouping Factors for Cables in Ducts

GROUPING No. of Cables	RATING CORRECTION FACTOR Cables in Multi-way ducts.		Cables in Single-way ducts 8 in. centres.
2 Cables	3 way	.88	.92
3 Cables		.82	.88
4 Cables	6 way	.74	.85
5 Cables		.70	.83
6 Cables		.67	.81

Notes: Soil Temperature = 59°F.
Temperature Rise of Cable = 99°F. (L.V. and 6.6 K.V.)
Temperature Rise of Cable = 90°F. (11 K.V.)
Final Cable Temperature = 158°F. up to and including 6.6 K.V. and 149°F. for 11 K.V.

Electrical Distribution as applied to Docks—continued

Table 3.2

Grouping Factors for P.I.L.C.S.W.A. Cables laid direct in ground
(Based on E.R.A. Report F/T.128)

	No. of Cables or Groups.	RATING FACTOR FOR AXIAL SPACING OF Touching	6 in.	12 in.	18 in.	24 in.
Twin and Multicore Cables in Horizontal Formation	2	.81	.86	.89	.91	.93
	3	.71	.76	.81	.84	.86
	4	.65	.70	.77	.79	.82
	6	.58	.64	.70	.75	.79
	8	.52	.59	.67	.72	.76
Twin and Multicore Cables in Tier Formation	2	.81	.86	.89	.91	.93
	3	.71	.76	.81	.84	.86
	4	.62	.69	.74	.77	.80
	6	.51	.59	.65	.68	.71
	8	.45	.53	.59	.62	.65

As an example of the use of the rating factor a 3 phase .20 square inch 11 K.V. paper insulated lead covered steel wire armoured cable will carry if laid direct in the ground, 290 amperes representing 5500 K.V.A. but if 8 such cables are laid in one trough each touching the other the current is reduced to $291 \times .52 = 150$ amperes (approx.) and the K.V.A. per cable reduced to $5500 \times .52 = 2860$ K.V.A.

The sustained overload rating (1 hour) may be obtained from Table 3.3 given below where the overload rating factor is related to cable diameter.

Table 3.3

One-hour overload Ratings of Cables laid direct in the ground
(Based on E.R.A. F/T.128)

Diameter of cable over lead.	OVERLOAD RATING FACTOR (ONE HOUR). Steady load = 50% Normal Maximum Rating.	Steady load = 75% Normal Maximum Rating.
0.5-in.	1.14	1.08
1.0-in.	1.17	1.10
1.5-in.	1.21	1.12
2.0-in.	1.25	1.15
2.5-in.	1.30	1.18
3.0-in.	1.35	1.22
3.5-in.	1.42	1.26

Thus in the previous example if the .20 square inch 11 K.V. 3 phase cable is carrying continuously a steady current of 145 amperes representing a load of 2750 K.V.A. and is laid direct in the ground a total current of $291 \times 1.21 = 355$ amperes representing a load of 6800 K.V.A. is permissible for one hour being an increase of 1300 K.V.A. over normal maximum rating. It should be noted that the diameter over the lead sheath of a 3 core .2 sq. inch belted 11 K.V. cable is 1.75-in.

(3) Short circuit capacity

Whilst cables and switchgear must be designed to carry the full load currents demanded by their ratings if connected to an electrical system of large capacity consideration must be given to the magnitude of the currents which can flow in the system under fault conditions. To illustrate this an example may be taken of a 3 phase generator or group of generators having a full load rating of 10,000 K.V.A. and an impedance of 10% designed for a voltage of 11 K.V. subjected to a dead short circuit at the generator terminals. Under these circumstances the voltage is maintained until demagnetisation takes place reducing the voltage and consequent steady value of the short circuit current to 2 to 3 times full load current. During the short period before demagnetisation the value of the current per phase is therefore $I_s = \frac{Eph}{Zph}$ and as the resistance is negligible this becomes $I_s = \frac{Eph}{xph}$ or using percentage values, the short circuit K.V.A. is equal to full load K.V.A. $\times \frac{100}{\%\ \text{impedance}}$ and in the example taken, the short circuit K.V.A. $= 10{,}000 \times \frac{100}{10} = 100{,}000$ K.V.A. (Symmetrical).

If, however, the generator cited in the example is connected to a substation by a feeder having a resistance of .3 ohms per phase a reactance of .6 ohms per phase, then the short circuit M.V.A. in the event of a fault at the substation will be reduced due to the impedance of the feeder cable as follows:

$$\text{Generator impedance per phase} = \frac{Eph \times \%\ \text{impedance}}{100 \times I_1} \qquad (3.1)$$

Where Eph = Voltage per phase

and I_1 = Full load current per phase

$$I_1 = \frac{K.V.A. \times 1000}{\sqrt{3} \times E} \qquad (3.2)$$

Where E = volts between phases and is $Eph \times 1.73$ for a 3 phase system

$$I_1 = \frac{10{,}000 \times 1000}{11{,}000 \times \sqrt{3}} = 524 \text{ amps.}$$

$$\text{thus } {}^*zph = \frac{\frac{11000 \times 10}{\sqrt{3}}}{100 \times 524} = \frac{6350 \times 10}{100 \times 522} = 1.22 \text{ ohms}$$

*in view of the small value of the resistance of the generator as compared with the reactance this may be regarded as reactance only i.e. xph = 1.22 ohms.

$$\text{Total impedance} = \sqrt{(r_c)^2 + (x_g + x_c)^2} \qquad (3.3)$$

where r_c = cable resistance
x_c = cable reactance
x_g = generator reactance (impedance)

$$Z = \sqrt{\cdot 3^2 + (1.22 + .6)^2}$$
$$\sqrt{\cdot 09 + (1.82)^2}$$
$$= \sqrt{3.4} = 1.844 \text{ ohms}$$ which indicates how small is the effect of the cable resistance in this case.

The total current on short circuit per phase is now

$$I_s = \frac{Eph}{1.844} = \frac{6350}{1.844} = 3440 \text{ amperes symmetrical}$$

$$= \frac{6350 \times 3440}{10^6} \text{ say 22 M.V.A. per phase}$$

and for a simultaneous fault on all three phases.

$22 \times 3 = 66$ M.V.A. i.e. a reduction from 100 M.V.A. due to Cable impedance.

If the fault current is asymmetrical, the phases in which non symmetrical conditions exist due to a D.C. component will have a fault current which may be 1.2 to 1.8 times that calculated as the method of calculation assumes symmetrical conditions. This "doubling" effect depends largely upon the ratio $\frac{r}{x_c}$ where r = the resistance and x_c = the reactance of the system and may have a value of 1.6 for values of $\frac{r}{x_c} = .1$ or as large as 1.8 for small values of $\frac{r}{x_c}$

As the "doubling" effect persists only over two to three cycles it can be neglected as far as cables are concerned but this aspect of fault currents will be dealt with further in Section IV dealing with switchgear.

Generally faults occurring at or adjacent to substation or power stations are more liable to "doubling" effect due to the lower $\frac{r_c}{x_c}$ ratio than distant faults where the ohmic resistance of the feeders tends to increase ratio $\frac{r}{x_c}$ and thus reduce the degree of asymmetry.

The current carrying capacity of cables under short circuit conditions bears little relation to the normal current carrying capacity and cases do occur where the size of cables supplying relatively small loads must be increased beyond that required for normal load conditions in order to prevent damage to the dielectric by the heat generated under fault conditions. An example will be given, but

Electrical Distribution as applied to Docks—continued

in general if a high voltage cable is short in length, small in area, and is near to the point of supply, then the cable area will have to be increased beyond that required for normal load.

H.V. Cables

The available fault M.V.A. at the supply point is usually indicated by the Supply Authority and due to the increased capacity of plant, feeders and substation equipment is generally not less than 250 M.V.A. in most areas.

Taking 250 M.V.A. fault current as an example

$$I_s = \frac{M.V.A. \times 10^6}{\sqrt{3} \times E} \qquad (3.4)$$

When M.V.A. = mega voltamperes E = line voltage and I_s = available short circuit current per phase.

$$\text{thus } I_s = \frac{250 \times 10^6}{\sqrt{3} \times 11000} = 13100 \text{ amperes per phase}$$

and the equivalent impedance of the supply point is

$$\text{given by } Z = \frac{E}{\sqrt{3} \times I_s} \qquad (3.5)$$

$$\text{i.e.} \quad Z = \frac{11000}{1.73 \times 13100} = .485 \text{ ohms which may be regarded}$$

as mainly reactance if the supply is stepped down from a higher voltage supply on account of the predominate reactance of the transformer.

Referring to Fig. (1.1)

The length of the cable connecting the Supply Authorities substation to No. 1 substation is 500 yds. and the cables are duplicated and of the same size, i.e. .15 square inch each, thus the equivalent cable is 250 yards of .15 sq. inch having a resistance of .1690 ohms per 1000 yards and a reactance of .0816 ohms per 1000 yards at a frequency of 50 cycles.

The total reactance from the point of supply and including the reactance of the supply system is

$$.485 + \left(\frac{.08196 \times 250}{1000}\right) = .485 + .02049 \text{ ohms} = .505 \text{ ohms}$$

and the resistance of the .15 cables from the supply point to No. 1 Substation

$$= .1690 \text{ per 1000 yards in ohms}$$

$$\text{thus the total resistance} = \frac{.1690 \times 250}{1000} = .0422 \text{ ohms}$$

The impedance from the supply point to No. 1 Substation including the impedance of the supply system is given by

$$Z = \sqrt{\Sigma r_c^2 + \Sigma x_c^2} \qquad (3.6)$$

Σx being the sum of the individual reactances and Σr the sum of the resistances.

It may be noted that if the cable data is given as inductance in

$$\text{millihenries } x = 2\pi \sim \frac{L}{1000} \qquad (3.7)$$

where L = millihenries and $\sim$ = frequency of supply the total impedance therefore at No. 1 Substation is $\sqrt{.505^2 + .0427^2} = .506$ ohms which clearly indicates the small influence on the total impedance the reactance has when short H.V. cables are under consideration having relatively small cross sectional areas. See Table No. 3.4.

Note: that reactance and resistance have been taken for 250 yards only as the two 500 yards long feeders are in parallel.

The value of the short circuit current at No. 1 Substation is from

$$\text{formula—} I_s = \frac{E}{\sqrt{3}Z} \qquad (3.8)$$

$$\text{i.e. } I_s = \frac{11000}{1.73 \times .506} = 12500 \text{ amperes per phase.}$$

The short circuit current at No. 2 Substation may now be ascertained: assuming the length of the ring main North leg is 2200 yards from No. 1 Substation to No. 2 Substation and the length of the South leg is 2900 yards. Thus the reactance of 2200 yards of .15 square inch cable is

$$\frac{.1690 \times 2200}{1000} = .3718 \text{ ohms and the resistance of the South leg is}$$

$$\frac{.1690 \times 2900}{1000} = .49 \text{ ohms}$$

$\therefore$ the resistance in parallel is $\frac{r_1 \times r_2}{r_1 + r_2}$ where $r_1 + r_2$ = separate resistances of the two cables (3.9)

$$\text{hence the parallel resistance} = \frac{.3718 \times .49}{.3718 + .49} = .211 \text{ ohms}$$

the reactances may be dealt similarly hence

$$\text{parallel reactance} = \frac{x_1 \times x_2}{x_1 + x_2} \qquad (3.10)$$

Where x_1 and x_2 = Separate reactances of the cables

$$\text{Reactance of North leg} = \frac{.08196 \times 2200}{1000} = .18$$

$$\text{Reactance of South leg} = \frac{.08196 \times 2900}{1000} = .2375$$

$$\text{Parallel reactance} = \frac{.18 \times .2375}{.18 + .2375} = .102$$

Thus the total impedance from and including that of the supply point is

$$\sqrt{(.485 + .02049 + .102)^2 + (.0422 + .211)^2} = .658 \text{ ohms}$$

Therefore the short circuit current available at No. 2 Substation

$$\text{is } I_s = \frac{11000}{\sqrt{3} \times .65} = 9680 \text{ amperes per phase}$$

$$\text{and the M.V.A.} = \frac{\sqrt{3} \times I_s \times E}{10^6} = \frac{\sqrt{3} \times 9850 \times 11000}{10^6} = 184 \text{ M.V.A.}$$

The worst case of cable loading under fault conditions is in the event of a fault of maximum proportions i.e. short circuit between all 3 phases with the ring main open when all fault current will be supplied through one leg only of the ring main taking the North leg.

Total impedance in circuit with the fault =

$$Z = \sqrt{(.0422 + .3718)^2 + (.18 + .485)^2} = .782$$

$$I_s = \frac{11000}{\sqrt{3} \times .782} = 8100 \text{ amperes per phase}$$

$$M.V.A. = \frac{11000 \times \sqrt{3} \times 8100}{10^6} = 155 \text{ M.V.A.}$$

The short circuit current carrying capacity of the .15 sq. inch cable may now be considered.

$$T = \frac{K \times .012 \times I_s^2}{10^6 \times a^2} \qquad (3.11)$$

$$\text{Where } K = 1 + .004\left(\frac{T_1 + T_2}{2} - 15\right) \qquad (3.12)$$

T = temperature rise °C.

T_1 = temperature of conductor before short circuit °C.

T_2 = temperature of conductor after short circuit °C. defined by temperature limits of cable dielectric.

I_s = fault current in amperes per phase.

a = conductor area per core in square inches.

from the above formulae the values given below have been calculated.

Table 3.4

Short time rating (seconds)	Current density in amperes per sq. in.
.5	150,000
1.0	106,000
2.0	75,000
5.0	48,000
10.0	33,000

Taking the figure of 155 M.V.A. i.e. 8100 amperes per phase fault current on the North leg of the ring main only and the current density in the cable is obviously

$$i\square'' = \frac{I}{a}$$

$$= \frac{8100}{.15} = 54000 \text{ amperes per sq. inch corresponding to a maxi-}$$

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mum short time rating of 5 seconds hence as instantaneous operation may be regarded as in the range of .2 to .3 second the cable is quite adequate.

Taking the case of the cable between the supply point and No. 1 Substation the available fault current is 12500 amperes approximately whether one or two cables are in service due to the short length and consequent small impedance hence if one cable only is in service at the time of a 3 phase short circuit at No. 1 Substation the current density in cable is

$$\frac{12500}{.15} = 83400 \text{ amperes per sq. inch.}$$

The load carrying capacity of the cable (.15 sq. inch) is now considered and in order to do this it is necessary to assess the loads at the various substations the diversity between substations taken as 1.1. The power factor is assessed at .8 or 80% on the H.V. side.

No. 1 Substation feeders from the supply point = 4175 K.V.A. approx.

*Feeder from No. 1 Substation to No. 2 Substation = 2020 K.V.A. approx.

Feeder from No. 2 Substation to No. 3 Substation = 1780 K.V.A. approx.

Feeder from No. 3 Substation to No. 4 Substation = 575 K.V.A. approx.

*With the North leg circuit only closed the South leg being isolated at No. 1 Substation figure.

Thus the current in the feeders from the supply to No. 1 Substation is 220 amperes per phase therefore a .15 sq. inch cable is adequate even when only one cable is supplying the No. 1 Substation, provided the cables are laid direct in the ground and spaced reasonably, see Tables 3.1, 3.2 and 3.3.

Considering the ring main under the condition*, the cable from No. 1 Substation to No. 2 Substation will carry the greatest load which is 2020 K.V.A. obviously the cable is quite adequate as the current per phase is 106 amperes only.

On account of the size of the motors at the graving dock and the hydraulic pumping station the electricity service to these is afforded at 11000 volts, the load at the graving dock being 820 K.W. or 1025 K.V.A. at .8 power factor. It is realised that an auto synchronous motor would probably be used but for the purpose of comparison the same power factor of .8 is being used,

$$\text{thus } I_L = \frac{\text{K.V.A.} \times 1000}{\sqrt{3} \times E} = \frac{1025 \times 1000}{1.73 \times 14000} = 54 \text{ amperes per phase.}$$

Table 3.1 indicates that a .0225 sq. inch cable is adequate to carry normal load but the possible current under the worst conditions approximates 184 M.V.A. or 9650 amperes, and the consequent current density is $\frac{9650}{.0225} = 428000$ amperes per sq. inch. Reference to Table 3.4 shows the cable to be inadequate for this duty, therefore, notwithstanding the fact that a .0225 sq. inch cable is of ample area for load carrying a larger cable must be installed, and to withstand short circuit conditions, a .15 sq. inch cable should be installed. Whilst it was indicated that the voltage drop is of relatively small importance on a H.V. cable of such small length it may be of interest to calculate this under the worst conditions, i.e. when the North leg of the ring main is supplying Nos. 2, 3 and 4 Substations with the South leg out of service between No. 1 Substation and No. 4 Substations. For a short length of cable as under consideration where the cable capacity is relatively small the formula

$$E_0 = \sqrt{(E_L \cos\theta + I_L r_c)^2 + (E_L \sin\theta + I x_c)^2} \qquad (3.13)$$

gives the relation between open circuit voltage E_0 and the voltage on full load E_L, in terms of load current I_L, resistance of cable r_c and reactance x_c together with the power factor $\cos\theta$ as a decimal, all in terms of per phase.

In this case assume voltage on load = 11000, $\cos\theta$ = .8.

	r	x	i	Volts ir	Volts ix	Item No.
Between Supply and No. 1 Sub.	.0427	.0205	220	9.4	4.5	1
Between No. 1 and No. 2 Subs.	.2725	.18	106	29	19	2
No. 2 Subs. and No. 3 Subs.	.102	.0485	93.5	9.7	4.5	3
No. 3 Subs and No. 4 Subs.	.1690	.0819	30	5	2.45	4

Table 3.4

Resistance, Reactance and Impedance of 1000 yards of Paper Insulated Twin and Multicore Cables, Belted and Earthed Neutral per 1000 yards at 60°F.

	660 volts.			6,600 volts,		11,000 volts.	
Conductor Area sq. in.	Resistance ohms.	Reactance at 50 ohms.	Impedance ohms.	Reactance at 50 ohms.	Impedance ohms.	Reactance at 50 ohms.	Impedance ohms.
.0225	1.128	.07917	1.308	.09468	1.1320	.1039	1.330
.04	.6308	.07220	.6349	.08492	.6365	.09274	.6399
.06	.4164	.06960	.422	.08058	.4241	.08750	.4255
.1	.2476	.06692	.2565	.07590	.2590	.08175	.2608
.15	.1690	.06368	.1806	.07140	.1835	.07647	.1855
.2	.1272	.06263	.1418	.06949	.1449	.07405	.1472
.25	.1013	.06268	.1191	.06732	.1217	.07332	.1245
.3	.0826	.062	.1033	.067	.1064	.07084	.1088
.4	.06147	.06175	.08713	.06606	.0924	.06946	.09276
.5	.05011	.06114	.07905	.06562	.0827	.06874	.08510

2% increase allowed for cable lay in the above table.

Notes :

As the above table is based upon a cable temperature of 60°F. the correction factors (t) given in Table 3.5 must be applied in the formula $Vd = \frac{\sqrt{3}\, L_L \times L \times Z \times t}{1000}$ where the final Temp. Rise = (81°F. for L.V. and 6.6 K.V. 72°F. for 11 K.V.).

Table 3.5

Temperature Correction Factors(t)

Temperature °F	Correction Factor (t)	Temperature °	Correction Factor (t)
60	1.0	140	1.18
104	1.10	149	1.20
113	1.12	158	1.22
122	1.14	170	1.24
131	1.16	220	1.36

$$E_0 = \sqrt{(E_1 \cos\theta + 1_r)^2 + (E_1 \text{Sm}\theta + 1X)_2}$$

$$= \sqrt{(6350 \times .8) + 29) + (6350 \times .6) + 19.)^2}$$

$= 6395$, and $6395\sqrt{3} = 11072$ volts or .655% voltage drop. Using the shorter method fully dealt with under L.V. Cables

$$Vd = \frac{\sqrt{3}\, L_L \times L \times Z_c \times t}{1000} \qquad Vd = 1.73 \times (\sqrt{29^2 + 19^2}) \times 1.2$$

$= 73$ volts or .56% voltage drop.

L_L = Load current in amperes.
Z_c = Impedance per 1000 yards of one conductor.
L = Route length in yards.
t = temperature correction factor Table.

From what it is seen, taking the section with the greatest voltage drop, the difference between E_0 and E_L is negligible, and therefore voltage drop does not enter into consideration on the H.V. side of the system in view of the high voltage employed and the relatively short distance involved on the average dock system. Where, however, there are two or more docks widely separated geographically and supplied from a common high voltage electrical system, the question of voltage drop may require consideration on the lines given above.

L.V. Cables

As previously indicated whereas the voltage drop on the H.V. system is not an important factor, on the L.V. feeders it may be the

Electrical Distribution as applied to Docks—continued

deciding factor in respect of cable size. An example will illustrate the method of calculating the cable sizes on the L.V. system and as previously there are four factors to be considered (1) The normal full load, (2) The short circuit current, (3) The voltage drop and (4) The overload capacity. Taking the feeder from the No. 1 Substation or supply point to power distribution pillar (1a) the following initial information is available.

Load = 347 K.W. at .7 power factor on $\frac{347}{\text{Cos}\,\theta} = 497$ K.V.A.

Cable Distance between No. 1 Substation and (1a) Distribution pillar = 450 yards.

Service voltage 415 volts.

Permissible voltage drop, in order to allow for the large transient current demands which invariably occur on dock systems, is 4% to 5% thus the total permissible voltage drop between phases is

$$\frac{415 \times 5}{100} = 20.75 \text{ volts}$$

$$I_L \text{ full load current per phase} = \frac{\text{K.V.A.} \times 1000}{E \times \sqrt{3}}$$

Where E = Line voltage × .95 i.e. 5% drop
= 415 × .95 = 395 volts.

$$I_L = \frac{497 \times 1000}{395 \times 1.73} = 725 \text{ amperes per phase.}$$

Using duplicate feeders the current per cable is $\frac{725}{2} = 362.5$ amperes. From Table 3.1 a cable having a sectional area of .4 square inches will carry 465 amperes if laid direct in the ground. From Table 3.2 the grouping factor = .81 thus the current carrying capacity per cable is 465 × .81 = 370 amperes and further the overload factor from Table 3.3 is approximately 1.25 when the normal load is 50% of the maximum rating, and 1.15 when the normal load is 75% of normal rating, the diameter of the cable over the sheath being 1.86 inches. Thus the overload ratings of the cables are 370 × 1.25 = 462 amperes and 370 × 1.15 = 425 amperes respectively for one hour duration per cable.

The voltage on open circuit may be obtained from

$$E_0 \sqrt{(E_L \text{Cos}\theta + I_L r_c)^2 + (E_L \text{Sin}\theta + I_L x_c)^2}$$

Where E_0 = open circuit voltage + E_L = full load voltage

$I_L r$ = the ohmic voltage drop and $I_L x$ = reactance voltage drop

r_c per 1000 yds. from Table = .06147 ohms

x_c per 1000 yds. from Table = .06175 ohms at 50 cycles

$$\text{ir}/450 \text{ yds.} = 362.5 \times .06147 \times \frac{450}{1000} (\text{per phase}) = 10.09 \text{ volts.}$$

$$\text{Ix}/450 \text{ yds.} = 362.5 \times .06175 \times \frac{450}{1000} (\text{per phase}) = 10.15 \text{ volts.}$$

$$\text{Phase voltage on full load} = \frac{395}{3} = 228 \text{ volts.}$$

thus no load voltage per phase =

$$\sqrt{(228 \times .7 + 10.09)^2 + (228 \times .7 + 10.15)^2}$$
$$= \sqrt{(159.6 + 10.09)^2 + (163 + 10.15)^2}$$

= 242.2 volts between phase and star point or 242.2 × $\sqrt{3}$ between phases = 420 volts

thus the voltage drop on full load is 420 - 395 = 25 volts.

A shorter method is to take the cable impedance and proceed as below

$$\text{Volts drop between phases} = \frac{\sqrt{3}\, I_L \times L \times Z_c . t.}{1000} \qquad (3.14)$$

Where I_L = Full load current
L = Route length of cable in yards
Z_c = Impedance of one cable per 1000 yards
t = Temperature correction factor

$$\text{vd} = 1.73 \times 362.5 \times \frac{450}{1000} \times .8713 \times 1.2$$
$$= \mathbf{28 \text{ volts.}}$$

The above method is not quite so accurate particularly at low power factors.

Note: The low power factor of .7 (70%) is taken to deal with the worst power factor condition on the L.V. System.

The cable temperature correction factor (t) Table 3.5 has been used in the shorter method in the formula $\text{Vd} = \frac{\sqrt{3}\, I_L \times L \times Z_c\, t}{1000}$ and in order to bring the more accurate formula E_0 =

$$\sqrt{(E_L \text{ Cos } \theta + I_L r_c(^2) + (E_L \text{ Sin } \theta + I_L x_c)^2}$$

in to line it is necessary to multiply the voltage drop due to the cable resistance by the factor (t). The selection of the factor from the Table 3.5 is made by taking the ambient temperature of 59°F. and adding the permissible temperature rise of 90°F. giving a final temperature of 149°F. the factor being 1.2 thus in the example above the volts drop due to resistance per phase = 10.09 volts therefore to take account of the increase in the resistance of the cable due to heating E_0 =

$$\sqrt{[159.6 + (10.09 \times 1.2)]^2 + (163 + 10.15)^2}$$

= 243.6 volts per phase or 243.6 $\sqrt{3}$ = 422 volts thus the voltage drop on full load is 422 - 395 = 27 volts which is in fair agreement with the shorter method, the higher voltage drop being due to cable temperature rise.

Two modifications are possible in order to reduce the voltage drop, first the size of the feeder may be increased to .5 square inch in section but there remains the disadvantage that in the event of the failure of one feeder the normal full load current cannot be carried by the remaining feeder as this will be grossly overloaded and in consequence damaged by excessive temperature rise.

Fig. 3.1.

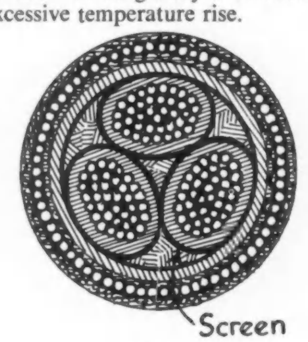


Fig. 3.2.

A more preferable layout is to provide three L.V. feeders from the supply point to the distribution pillar 1a, when under normal conditions of full load each feeder carries $\frac{730}{3} = 243$ amperes per phase which will give a voltage drop of approximately 4% when transmitting full load at a power factor of .7 or 70% further in the event of failure of one feeder, the two remaining can safely deal with the full load of 347 K.W. at 70% power factor (.7) without involving damage due to cable temperature rise. The voltage drop will of course increase to about 6% but this will not materially impede the operation of the appliances. For insurance against breakdown and damage to cables due to overloading the scheme of distribution from the distribution pillar to the plug boxes serving the cranes should also be by three .4 square inch cables generally as shown on drawing No. 1.1 the additional cables being shown as a dotted line. The whole of the L.V. feeders and distributors may be dealt with in a similar manner. For preliminary calculations a useful rule is: At 1000 amperes per square inch a copper conductor carrying current at this density will experience a drop in voltage due to ohmic resistance only, of 2.48 volts or approximately 2.5 volts per 100 yards of conductor length, thus a .5 square inch cable 1000 yards long carrying 500 amperes at a density of $\frac{500}{.5} = 1000$ amperes per sq. inch, has a ohmic voltage drop of $\frac{1000}{100} \times 2.5 = 25$ volts, and if this a portion of a 3 phase system then the ohmic voltage drop between phases is $\sqrt{3 \times 25} = 43.4$ volts. By

Electrical Distribution as applied to Docks—continued

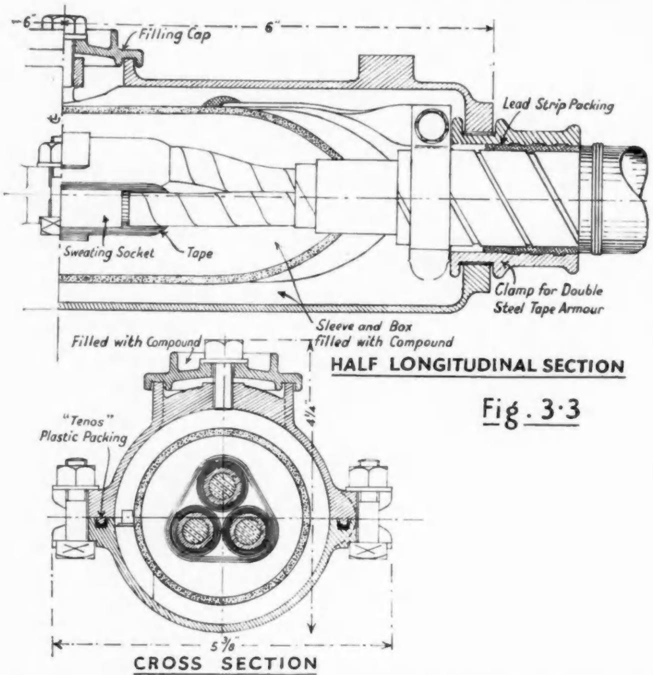


Fig. 3·3

Table 3.4 the resistance of a .5 square inch cable is .05 ohms and at 500 amps this gives a voltage drop per conductor of $.05 \times 500 = 250$ volts which gives an indication of the accuracy of the 2.5 volt/100 yards rule. If the current density is 500 amperes per sq. inch i.e. 250 amperes in the example then the voltage drop is 12.5 volts and if the density is 2000 sq. inch then the voltage drop is 50 volts. It should be noted that on A.C. systems that cable reactance as previously dealt with, does require consideration but for cable sizes up to .1 square inch the effect is not sufficient to preclude the use of the 2.5 volt rule for preliminary investigation upon short cables.

Finally in order to calculate the loss due to ohmic resistance—the watts loss=current ^{2}x resistance=I^2r which is quite a simple matter. To estimate the energy loss, however, in kilowatt hours over a period is a very much more difficult matter because in view of the fact that the loss is proportional to the square of the current, the root of mean square taken over the period cannot be used in the formula I^2rt where t=time and r=resistance. It is necessary, therefore, to integrate the I^2rt for small periods using a specimen load curve. This aspect, however, is fully dealt with in Section No. XI " Economics."

The Physical Aspect of the Cable System

Types of Cable in use on Dock Distribution Systems

The types available and very suitable for dock installations designed for both H.V. and L.V. up to and including 11 K.V. are 3 and 4 core belted having shaped or circular cores, the former giving a smaller overall diameter for the same core area, insulated with oil compound, impregnated paper, lead or aluminium sheathed and wire or steel tape armoured.

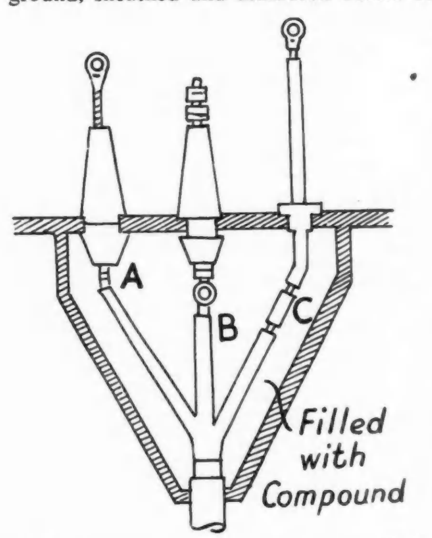
For voltages of 22 K.V. and 33 K.V. oval cores are preferred on account of the reduction of localised electrical stress. Up to and including voltages of 11 K.V. the belted type of cable is quite satisfactory. Fig. 3.1, but in view of the fact that the dielectric or insulation in a belted cable is not homogeneous there is a possibility of voids which may become the sites of electrical discharge and consequent insulation breakdown, it is desirable to use a screened cable above 11 K.V. Fig. 3.2. Where cables are installed in vertical positions as in culverts under dock entrances drained or non-bleeding cables are utilised to prevent the draining of the impregnating compound by gravity, which due to the static head produced may cause bursting of the lead sheath, sealing ends or dividing boxes.

Cable Laying

General practice for dock systems is to lay the cables direct into the ground in a suitable trench which is subsequently filled in and the ground made up. It is desirable, however, prior to laying cables to ascertain the nature of the soil with respect to acidity. Made up ground with a large ash content is particularly undesirable and in such cases a covering of at least 6-in. thickness of neutral clay should be provided all round the cables for the entire route length. The depth at which cables are laid varies from 2-ft. 6-in. to 3-ft. below the surface, the exception being under rail crossings where the laying depth is increased to 4-ft., non metallic pipes or ducts being provided for protection. It is important also that in increasing the laying depth from 2-ft. 6-in. say to 4-ft., the change in depth is effected gradually. Road crossings may be similarly dealt with except in this case the depth need not exceed 3-ft. in normal circumstances. Where it may be necessary to lay cables under large concreted areas or along roadways, ducts with " draw in " pits provided at suitable intervals along the route should be utilised. Cables should not be in contact at any position of the route with metallic structures, water and gas pipes etc. As indicated in the Section on Cable Rating the distance the cables are apart in the trench greatly influences the maximum current which the cables will carry and also a separation is desirable to prevent damage to healthy cables by a faulty cable hence a distance of 12 inches between cables laid in the same trench is desirable where possible. Cables carried under the dock entrance in culverts must be of the drained or non-bleeding type, preferably cleated to the culvert wall by adequate wood cleats designed to take the weight of the cable, the cleats being spaced a distance apart not exceeding 6-ft. Where culverts are not available the cable may be recessed into the dock wall and sill of the dock entrance, the cable being of the submarine type, and it is desirable in view of the possibility of damage to provide a junction box at each side of dock entrance fitted with mechanical connections between the underground and submarine cables.

Cables installed above ground

In some situations it may be convenient to instal cables above ground, sheathed and armoured cables being used and supported by hangers (non frictional) fixed to concrete or composition posts or on the sides of buildings or structures. The supports should not have a greater spacing than 6-ft. and referring to section on Cable Rating it is seen that the current carrying capacity is reduced due to the lesser thermal conductivity of air with respect to soil but it also does indicate that wide spacing is now not so important for the same reason.



A, B&C-Methods of Terminating Tails

Fig. 3.4.

Joints

The joints between the lengths of cable may be of the wiped lead sleeve type enclosed in a cast iron box for H.V. cables (Fig. 3.3) whilst for L.V. cables the lead sleeve is often dispensed with. These joints may be regarded as part of the cable and are in effect solid connections between lengths of cable. It is preferable that they should be in the straight run of the cable route and it is good practice to support the joint by means of a small concrete foundation. Joints for cables installed above ground may be bolted to concrete foundation blocks above ground level.

For maintenance purposes it may be desirable to build a small protecting enclosure of brick or precast concrete slabs provided

Electrical Distribution as applied to Docks—continued

with a suitable cover. The space between the sides of the enclosure and the joint box being filled with sand. Where isolation is required, it is preferable to provide a distribution pillar, but if this is not possible a disconnecting type ground junction box installed in a protecting enclosure will give the required facility, but as against the distribution pillar it does suffer from the disadvantage of the possibility of ingress of surface water and also less space for links and fuses is available.

Cable Terminations (trifurcating boxes)

These are generally as Fig. 3.4 and are similar in basic design to a joint box. The cable if on the walls of buildings or structures, should have adequate protection from ground level to 7-ft. above ground level as a maximum.

Pilot Cables

These are preferably laid in a separate trench or widely separated from the main cables in order to ensure that a faulty main cable does not put the pilot system out of action, and possibly shut down the whole system. The laying, jointing and termination should follow the same practice as for main cables except there is no necessity for wide spacing between pilot cables on the score of current carrying capacity.

Phase rotation at terminations should conform with B.S.S.171 Appendix J Vector group No. 41 DY 11.

Cable protection against mechanical damage may be provided by precast interlocking tiles laid above the cable 3-in. to 6-in. below ground level, marker blocks being provided at ground level at intervals and at all changes of direction to indicate the cable route. Joint boxes if provided with enclosures may have an indication on the enclosure cover, where enclosures are not provided a ground level marker is adequate.

Bonding

Bonding of cable sheaths and armouring is important in order to prevent potential differences which may cause arcing between sheath and armour. All bonds should have a sectional area not less than the equivalent of the sheath and armour combined. Similarly bonds across joint boxes should have the same equivalent cross sectional area.

(To be continued)

Marine Pilotage

History of Development and Service

(Specially Contributed)

(Concluded from page 292)

Rates for Pilotage.

An analysis of the manner in which pilotage rates are regulated produces even in the minds of those engaged in the shipping industry a profound state of confusion. In each port there will be some person whose business it has been to carefully follow the local scene, but even his precise knowledge will be of only general guidance in contemplating the rates at another port. It is in this important matter that pilotage has retained so many relics of previous customs and practices; parliament has never felt strong enough, or perhaps regarded the need as being in the best interests of the industry, to sweep away all the different rates and methods of determining the value of a pilot's services and substituting an overall basic rate or rates. In the U.K. pilots remain licensees and are "self employed," and the pilotage rates instead of being an overall fixed sum for so many hours use of the pilot's skill and knowledge, seek to split up his services into stages, into periods of detention, waiting time, travelling time, anchoring, trial trips, tonnage of a vessel assessed on gross register, sometimes on net register, and other cases in which both are combined with footage or a draught rate and other extra charges.

The difficulty of striking a level of rates which will provide the pilots with a reasonable remuneration from these various sources is made more complex by the fluctuations which occur in the shipping traffic to and from a port. The impact of a falling off in trade is immediate on pilots' remuneration, whilst the rates themselves being regulated by byelaw for which ministerial approval is necessary, have to go through the various stages of advertisement, objections have to be heard and answered and the whole gamut of a somewhat cumbrous procedure followed through on each and every occasion when rates require to be altered. Some examples will serve to illustrate the wide differences which exist in the method of assessing pilotage rates.

In the London District vessels are charged a tonnage rate per 1,000 gross registered tons and a footage rate depending on the draught of water. These rates vary according to the particular part of the District, and the District is divided for the purpose of rates into about 40 different stages, and in addition there are charges for special services such as attending whilst compasses are being adjusted, for various mooring or unmooring activities, and for detention. A charge is also made for shipping or landing a pilot by means of a Trinity House pilot boat, and this charge oddly enough is based on net registered tonnage and may range from £2 for a vessel under 250 net registered tons to £20 for a vessel over 40,000 net registered tons. It will be observed that all three of the more obvious criteria are applied, gross registered tonnage and draught of water for pilotage charges and net registered tonnage for boarding and landing charges, whilst some pilotage activities cannot be brought under any one of these headings. Within the greatest port in the world one would expect to find at some time or another every type of craft which trades or voyages to this country, and no doubt these charges stem from a time long ago when some arbitrary figure was adopted by the pilots along the lines of "£12 and as much more as the pilot could extract." As ships increased in number and size and the rates came to be regulated the network of rates was added to so as to bring any new pilotage act within the rate structure. Each new development would not by itself justify a review of the system of rates, and piecemeal additions and adaptations applied through years which have been marked by great changes in the shipping industry have produced pilotage rate schedules which lack any coherent theme which can be related to or identified with the value of the services rendered.

Although the schedule of rates drawn up for each District seeks to cover every form of activity in which a pilot may be engaged, the Pilotage Authority are usually empowered to fix a charge for a service rendered by a pilot to a vessel when such service is not covered by the approved rate schedule.

The revenue from all sources may be broadly grouped under four headings, the Common Purse, the Cutter Fund, the Pilot Fund and the Pilots' Benefit Fund. There are extraneous payments such as travelling expenses and payments for special services and to selected pilots. The distribution of the Common Purse is a somewhat complex arrangement, but the revenue and disbursement of the three other funds is more clearly identifiable. The Cutter Fund provides the money for maintaining the pilot vessels and the service, the Pilot Fund bears the cost of administration, and the Benefit Fund is the Capital Fund from which pensions are paid. In the days when a pilot operated independently the gross figure for receipts from pilotage could give very misleading information as to the actual earnings or net remuneration received by the pilot. There were the costs of his boat, crew, provisions and maintenance to be paid for before he was able to assess his own actual reward for piloting, and the Pilotage Act 1913 and the Pilotage Returns Order set out the precise form in which the details of the returns of income are to be reported annually to the Ministry. Nowadays, where the cutters are owned and the

Marine Pilotage—*continued*

service is maintained by the Pilotage Authority for the District from the Cutter Fund, the difference between average gross earnings and average net earnings represents the amount paid into the Pilot Fund and the Pilots' Benefit Fund. For a pilot who is described as having net earnings of £1,400 per annum, a sum of about £140 (this varies according to a percentage deduction) may have been paid into the Benefit Fund to swell the Pension Fund. All original revenue to all pilotage funds is, of course, paid by the shipowner.

All the Trinity House outports, and they number 40, come within the purview of a code of General Byelaws, each District, however, has its own schedule of charges, and in almost every case the charges are made on a combination of net registered tonnage and draught, although the exemptions from pilotage which are set out in the Trinity House General Byelaws relate to Gross Registered Tonnage. In Districts where sailing vessels are occasionally still encountered an extra charge is made, whilst in some Districts the charge for outward pilotage is less than for inward, and when it is desired to induce vessels to call in for bunkers or stores the pilotage charges are reduced on a vessel calling solely for these purposes. Coastwise vessels are sometimes charged less than foreign-going vessels.

The Isle of Wight District is one of the more important Trinity House outports and is distinguished also by being the terminal for the largest vessels in the world. This District is divided into many geographical stages and again into harbour pilotage, river pilotage, inward and outward pilotage, in which the charges are based on so much per foot of draught. These charges cover the act of docking and mooring alongside the wharves at Southampton, but when a vessel is piloted into or out of the inner dock additional charges are made which are based on the vessel's net registered tonnage. If a pilot is boarded or landed by a Trinity House pilot boat a charge based on net registered tonnage is made, but if a pilot is boarded or landed by a pilot boat which is owned by the pilots the charge is based on draught.

The rates for pilotage in the Clyde District are based on gross registered tonnage, and so also are the boarding and landing rates. The District is divided into stages or sections for the purpose of charging pilotage rates, and there are extra charges for shifting vessels within the District, attendance whilst compasses are being adjusted, trial trips, launchings, anchoring and detention or for consultation. The revenue from pilotage rates is pooled after deductions have been made for Pilot Fund and Pilots' Benefit Fund and shared out in a manner agreed by the pilots and the Authority. A somewhat unusual feature of the Clyde rates is that rate which relates to deep sea pilotage; this sets out a table of charges for employing a pilot outside the Clyde Pilotage District, this rate is irrespective of tonnage and as a byelaw it would seem to be of doubtful validity.

The Liverpool District bases both pilotage dues and pilot boat rate on draught, and after the usual deductions the pilotage dues are carried to a Common Fund and shared among the pilots in accordance with the byelaws. The authority for charging the boat rate is contained in the Liverpool Pilotage Order, and unlike some other Districts the boat rate is chargeable on every vessel incurring pilotage dues. In some Districts the boat rate is only chargeable if a boat is used to board or land a pilot. There is also an unusual provision in the Liverpool Order which authorises a percentage deduction from the Boat Rate towards the Pilots' Benefit Fund in addition to the percentage deduction made from the pilotage dues.

The Bristol Channel Districts, Swansea, Gloucester, Cardiff, Barry, Newport and Bristol all base their pilotage charges on net registered tonnage, so also does Belfast, whilst Manchester and the Tees use gross registered as the basis.

The subject of tonnage and ship measurement under British rules is rather complex, and the application of these rules is the special province of a department of the Ministry of Transport and Civil Aviation. The following definitions will give some idea of the various methods used for describing the magnitude of a ship.

Under Deck Tonnage.

This is the measure of the total internal capacity of a ship in "register" tons from the top of the "floors" or ceiling if situated thereon to the tonnage deck. The unit of measurement of a ton is 100 cubic feet. The tonnage deck is the upper deck in all ships which have fewer than three complete decks and the second deck from below in all other ships. A poop, bridge, forecastle, shelter deck and deck houses would not be included in such a measurement. The unit of 100 cubic feet bears no relation to the space required for any special purpose or the stowage of any particular commodity; it is merely a convenient figure established many years ago. For a freight ton a figure of 40 cubic feet is used.

Gross Registered Tonnage.

This is a measure of the internal volume of all enclosed spaces in the ship and is equal to the tonnage below the tonnage deck plus the tonnage of all enclosed spaces above that deck.

Net Registered Tonnage.

This is the residual tonnage after the various allowances for propelling machinery space, crew space, navigation and other spaces have been deducted from the gross registered tonnage. It is the figure which is usually cut into the main hatch coaming and that on which dock dues are usually paid. The approximate ratio of gross to net tonnage is about 3/2, although the construction of a particular ship may make this a wide approximation.

Dead-weight Tonnage.

This is the number of tons of 2,240 lbs. required to sink the vessel in the water to her load-line and will include stores, bunkers and cargo.

Displacement Tonnage.

This is the total weight of the ship in tons of 2,240 lbs., so that displacement less the deadweight is the light weight of the ship.

Draught.

This is the distance from the lowest part of the keel to the water-line at which the vessel is floating.

When pilotage rates are based on tonnage they are usually on a rising scale and the ship of large tonnage pays more than the ship of small tonnage; the act of pilotage is more onerous and calls for experience and a high degree of skill. A scale of charges which places a ship in the highest possible group for tonnage purposes would at first sight appear to provide the highest income to the pilotage funds. If such a scale were used it would, presumably, be based on loaded dead-weight tonnage, and it would be manifestly unfair to charge an unladen ship on such a basis. A vessel of 7,000 tons gross and 4,000 tons register may carry a dead-weight of 10,000 tons. The gross tonnage is the next highest assessment and is unchanging, but in order to bring the vessel's carrying capacity within the orbit of the charges a draught element is introduced so that at some ports a loaded vessel will pay more than a vessel in ballast. In those ports which are both import and export centres a schedule of rates based on draught may produce a maximum revenue to the pilotage funds, but a schedule based on gross or net register tonnage would appear to be simpler in application and could be pitched at a level to bring in the appropriate revenue. The latter method may, however, be affected by a change in the method of tonnage measurement or in the allowances made when arriving at the net figure. An example of this occurred recently when under the Merchant Shipping Act 1954 the allowances for space occupied by propelling power were altered and many ships of about 5,000 net register were re-measured and the resulting net register tonnage was reduced by some hundreds of tons. The owners of such vessels were immediately able to effect a not inconsiderable saving whereever rates for dock dues or pilotage were based on net registered tonnage. Whilst harbour authorities expressed their views on this alteration the effect on pilotage income seems to have passed without prior consultation or subsequent comment.

The net registered tonnage of a ship is a significant figure when a shipowner seeks to limit his liability.

The fact that at one port the pilotage rates are based on gross

Marine Pilotage—continued

tonnage and therefore the rate per gross ton is less than per registered ton of the port which bases its rates on net registered tonnage is not really important because the rates are designed or fixed at a level which will bring in sufficient revenue to give a certain number of pilots a reasonable reward. There would, however, appear to be some advantage in selecting a unit or criteria of measurement which could be applied at all ports, and the gross registered tonnage of a ship seems to be a label which will abide unaltered for the life of a ship.

It is in this particular sphere of tonnage measurement that some Liberian, Monrovian and Panamanian registered ships gain a considerable advantage. The certificates of measurement issued by these countries are not in accordance with the British standard of measurement, and it is not uncommon to find that an arbitrary surcharge is made on such vessels by dock and pilotage authorities with the alternative of being re-measured according to British rules. The fact that the surcharge is paid would seem to indicate that there is still a fairly good margin in favour of the ship.

For many years it has been the practice to adjust pilots' earnings by means of a percentage increase or decrease on the basic rates which were fixed perhaps 20 or 30 years ago. These adjustments have not always been upward, and with the intervention of a war a very complicated system has now resulted and it is often a matter for careful study to identify the prevailing rate from the maze of amending byelaws. Because, perhaps, of the inadequacy of the basic rates and the change which has taken place in the assessment of what constitutes a day's work, there has been a steady growth of rates for special services of one kind or another.

There are some circumstances in which a pilot may become entitled to a salvage award, but the unique position which a pilot occupies in relation to a vessel requiring advice or local knowledge requires the most careful assessment when a vessel is in difficulty or distress.

Sickness.

Several pilotage authorities have an arrangement whereby a pilot who is absent from duty on account of sickness through no fault of his own receives some form of sick pay, but there are other Districts in which the byelaws state that a pilot is to receive no share of the common pool for absence when sick. This latter arrangement may appear to fall harshly on the sick pilot, but in some Districts the pilots prefer to make their own arrangements in this matter and their private scheme is usually supplemented by some form of insurance.

Pilots' Pensions.

The Pilotage Act 1913 authorises the Pilotage Authority to make byelaws setting out the deductions to be made from pilotage dues for the purpose of forming a Benefit Fund from which pilots' pensions can be paid. The Authority act as trustees of the fund and arrange for it to be invested, and it is assessed from time to time by an actuary in order to determine the amount of pension to be paid to a retired pilot, to the widow or the children. The amount of the deduction made from pilotage dues for this purpose varies in each District, and the schemes also vary widely, but generally speaking owing to the slow growth of the Capital Fund the pensions paid are somewhat meagre and it may happen that a man who has been a pilot for 35 years and whose annual income on retirement is about £1,400 may receive a pension of about £5 10s. per week.

In most foreign ports the status of the pilot in relation to the master of a vessel is viewed very much in the same way as it is in this country. In European ports there are wide differences in the terms under which pilots are employed, ranging from State control under the local Admiralty to private companies in which the pilot shareholder may require to find several thousand pounds. In some cases the pilots are salaried and in other cases the pilot's earnings rise and fall with the flow and ebb of shipping, as in this country. The particular position of the Suez Canal Pilots has received, perhaps, far more publicity than the situation warranted, and the rapid manner in which experienced pilots' positions were filled without serious inconvenience to shipping has brought into prominence the rather elaborate and prolonged scheme of training employed by the Suez Canal Company.

The subject of pilotage has been a vexed problem for centuries, and the foregoing gives a brief outline of some of the anomalies which exist and the wide diversity of methods and qualifications. The time cannot be far distant when the whole scheme of things in the world of pilotage will have to be reviewed and brought more into line with other industries.

High Speed Launch for Lake Maracaibo

First Commercial Use of Deltic Engines

The first of three high-speed passenger vessels, each powered by two Napier Deltic engines, has successfully completed its trials in Southampton Water. This is the first time the Deltic diesel engine, hitherto fitted in naval vessels and, until recently, on the Admiralty secret list, has been put to commercial use.

These launches, built for Cia Shell de Venezuela, will operate on the 8,000 sq. miles of Lake Maracaibo where the Shell Company is conducting large-scale marine drilling operations some forty miles off-shore. Engineers, technicians and drilling staff working on the drilling rigs have to be transported by water to the scene of operations. As the men have to spend a considerable time travelling to and from work, it is desirable that this should be reduced to a minimum. The new craft have been designed to transport up to 45 passengers at a speed of over 30 knots, which is faster than any other vessels at present in use for this purpose. On trial, a mean speed of 31.2 knots was recorded.

Designed and constructed at Southampton by John I. Thornycroft and Co., Ltd., the vessels are $68\frac{1}{4}$-ft. in length, $17\frac{1}{2}$-ft. in breadth, $9\frac{1}{4}$-ft. in moulded depth and have a draft of about $5\frac{1}{2}$-ft. Each of the two nine-cylinder opposed-piston two-stroke cycle engines with ahead and astern reduction gearbox, drives a separate propeller. The engines are capable of 865 s.h.p. in temperate latitudes but are rated at 825 s.h.p. in the conditions obtaining in Maracaibo. Corresponding propeller shaft speed is 712 r.p.m. The outward turning propellers are of nickel aluminium bronze.

The new launch undergoing trials at Southampton.

A centrifugal scavenge blower at the "free end" of the engine is driven from the phasing gearing by a torsionally flexible shaft running through the cylinder block. The three blower outlets each communicate with a separate induction trunk that serves a complete bank of cylinders.

The reversing mechanism consists of two constant-mesh gear systems, one ahead and one astern, the appropriate gear train being connected by hydraulically loaded plate-clutches. The clutches are connected to the output shaft from the phasing gear train and therefore run at slightly over crankshaft speed. Controls for the clutches are inter-connected with the engine power control.

High Speed Launch for Lake Maracaibo—continued

Each engine has been fitted with a combustion-type starter in which a cartridge is fired into a cylinder containing a piston mounted on a helically splined shaft carrying a Bendix-type claw coupling. The starter is mounted on the phasing gear casing, its claw engaging with a similar one on a gear meshing directly with one of the upper crankshafts. Five cartridges are contained in a rotary breech which is indexed and electrically fired from the engine control compartment. The starting switch operates, in turn, priming of the engine lubricating oil and fuel oil systems before firing the cartridge. A time switch automatically indexes the breech for the next start. To assist the intake of the circulating water, suitable internal scoops are fitted to the hull of the vessel. The engine-driven water circulating pumps draw water through these, the valves and strainers.

After passing through engine-coolers, heat-exchangers, etc., the water is discharged overboard. Arrangements are made for the introduction of discharge circulating water into the exhaust system at shipside outlet and also to the stern-tubes for lubrication of the Cutless bearings.

Exhaust gases are led from the 6-in. bore manifolds via flexible steel exhaust pipes and bends and lightweight Burgess silencers to the hull's side. There are three exhaust-leads per engine with exits a suitable height above the waterline.

Spare engines will be made available at a local depot in Venezuela to enable a quick engine change to be made in any one of the craft when a routine overhaul becomes necessary. Thus no craft need be out of service for more than a few hours and a continuous night and day ferry service between the shore and the drilling rigs is assured.

The engine room is well ventilated. Mathway steering gear with car-size helmwheel control is employed to operate twin steel balance spade-type rudders. The craft are of steel because hulls are often struck by driftwood.

The main deck, forward passenger flat, bulkheads above the lowest strakes, and the superstructure are of aluminium alloy. Construction is partly riveted and partly welded. Three watertight bulkheads divide the vessel into fore peak, passenger cabin, machinery space and steering-gear compartments. The superstructure consists of a roof over the passenger cabin and a wheelhouse shelter, the sides of which are continued aft to form a coaming. Three Kent clear-view screens have been fitted.

The deck aft has been suitably strengthened for carrying deck cargo, and has ample clear space for the stowage of equipment being carried to the oil-drilling rigs.

The passenger cabin has 14 sliding windows 2-ft. by 1-ft. and the forward apron three 9-in. diameter portholes, the side ones being of the opening type. The cabin is ventilated by means of three light-alloy trunks leading from the fore side of the wheelhouse in conjunction with two Ranburn Magneto fan-exhaust vents fitted to the cabin top port and starboard. The engines are completely controlled from the wheelhouse by Teleflex gear. Access to the engine room is through a hatchway in the main deck on the port side just abaft amidships.

To obtain the minimum beam the engines are arranged with one $2\frac{3}{4}$-ft. behind the other, permitting easy access. There is a Teddington control panel which operates automatic starting from a push-button. Fuel tank space is provided abaft the engine room in the steering-gear compartment.

A 200 ampere-hour lead-acid battery supplies power for the electrical equipment associated with the Deltic engines and for general services. The accumulator is charged by two 720-watt C.A.V. dynamos, one for each engine. Two Stuart Turner electrically driven pumps have been installed for bilge duties.

There are two searchlights, a headlight and navigation and internal lights.

The launch has been constructed under Lloyd's Register supervision but is not classified. Special attention was given to thickening-up the bottom plating to $\frac{1}{4}$-in. in way of the propellers.

The cost of the prototype is £75,000—£100,000 and the launch is being shipped to Venezuela in the Royal Mail liner "Teviot."

The Deltic engine is now in full production for marine and industrial purposes at the Liverpool Works of D. Napier and Son Ltd.

Obituary

Alfred Henry James Bown, O.B.E., F.C.I.S., M.Inst.T.

We deeply regret to announce the sudden death at the age of 58 of Mr. A. H. J. Bown, a well-known member of the port industry and a good friend to this Journal for many years.

Mr. Bown was a native of Bristol and was educated at Queen Elizabeth's Hospital, afterwards commencing his career with the Guardian Assurance Company, Ltd., Bristol, with whom he worked from 1912 until 1920, during which time he also was on active service in the First World War. He joined the Port of Bristol Authority in 1920 and became their commercial representative in 1931, by which time he had completed his final examinations for the Chartered Institute of Secretaries (1929) and the Institute of Transport (1931).

In 1934 Mr. Bown was appointed by the River Wear Commissioners to the position of commercial representative at the port of Sunderland. His principal task in this capacity was the development of new trade, and he was responsible for the inauguration of Swedish and Finnish services as well as the development of coastal traffic. In January, 1938, he was made assistant general manager and, in 1940, became General Manager and Clerk. He was also appointed general manager to Sunderland Corporation Quay and clerk to the River Wear Watch Commissioners.

Since the end of the Second World War, Mr. Bown piloted through the Ministry of Transport a £1 million modernisation scheme for the port of Sunderland and he lived to see the scheme completed. He was engaged on further schemes for port development at the time of his death.

He was a member of the National Executive Committee of the Dock and Harbour Authorities' Association and a past chairman of the North-East Section of the Institute of Transport. He was also vice-chairman of the Tyne and Wear Port Employers' Association, and a member of the national Council of the Church Schools Co. Ltd. He was keenly interested in the work of the Sunderland branch of the Missions to Seamen.

Mr. Bown contributed many articles to maritime publications and was the author of three books related to the port industry, "Port Operation and Administration," which he wrote in collaboration with Mr. C. A. Dove, "Port Economics" and "Introduction to Port Working." In 1951 he was awarded the O.B.E. in recognition of his services to the port industry.

Management Changes at Port of Liverpool

At a meeting of the Mersey Docks and Harbour Board last month it was announced that Mr. Francis H. Cave, their General Manager and Secretary for the past two years, is to retire on 17th March next and will be succeeded by **Mr. A. S. Mountfield,** Deputy General Manager and Secretary.

Mr. Mountfield was educated at the Merchant Taylors' School, Crosby, and since entering the service of the Board in 1918 has been on the staff of the General Manager's Department. He has represented the Board on many Committees and Conferences and in recent years, has travelled on the Continent studying port operation and also in Canada and the United States in connection with the possible expansion of trade resulting from the development of the St. Lawrence Seaway.

Early this month it was further anonunced that **Mr. Leslie Miller** has been appointed Principal Assistant to Mr. A. S. Mountfield.

Mr. Miller entered the service of the Mersey Docks and Harbour Board in 1908 and, during the earlier years of his career, gained experience in the Check Office and the Harbour Master's, Warehouse, Accountant's, and Treasurer's Departments. After serving with the Army in the First World War, he was transferred to the General Manager's department and promoted to be an Assistant General Manager in 1954. He is the Board's representative on the local Dock Labour Board and Chairman of the Pilotage Sub-Committee of the Dock and Harbour Authorities' Association.